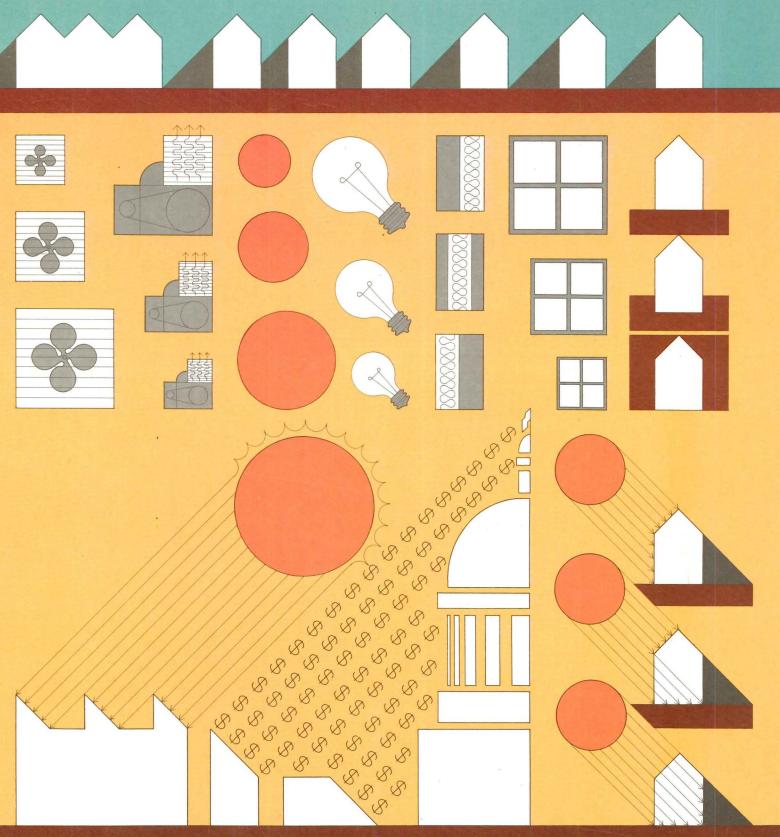
Progressive Architecture

April 1979 A Penton/IPC Publication



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ng better is not just a matter of shedding e footcandles of light on a subject. It's a er of increasing the usefulness of what there is. And the most accurate measure sefulness is Equivalent Sphere Illumina-(ESI).

measures precisely how well a viewer can what he's doing while performing various s. In the comparison chart, notice how C-60 System, with 24% fewer footcandles 40% fewer watts per square foot, pros an ESI level significantly higher than the ssed troffer system.

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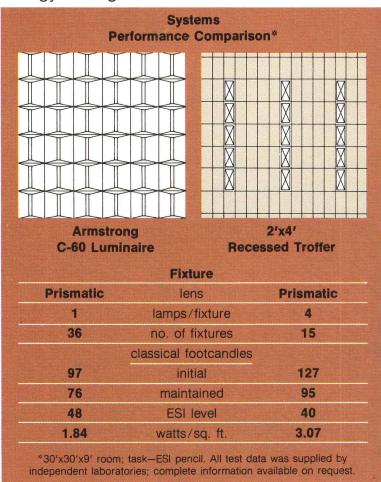
ause of the uniformity of light, there's less to place fixtures over specified work locas, making it an ideal system for open plances. It's aesthetically more pleasing, too.

ntegrated ceiling system.

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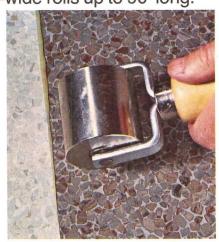


ecified commercial floors. Another is the stem that makes it work.

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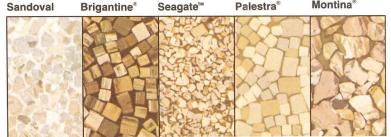
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Progressive Architecture (ISSN 033-0752) is published monthly by Reinhold Publishing, A Division of Penton/IPC. Philip H. Hubbard, Jr., President; Harry I. Martin, Vice-President. Penton/IPC: Thomas L. Dempsey, Chairman; Sal F. Marino, President; N.N. Goodman, Jr., Benjamin L. Hummel, Joseph Lipka, Paul Rolnick, Executive Vice-Presidents.

Executive and editorial offices, 600 Summer St., Stamford, Conn. 06904 (203-348-7531).

Subscription information:

Send all subscription orders, payments, and changes of address to Progressive Architecture, P.O. Box 95759, Cleveland, Oh 44101. Subscriptions payable in advance. Publisher reserves right to refuse unqualified subscriptions. Professional rate of \$12 per year is available to architectural and architectural-engineering firm personnel and architects, designers, engineers, and draftsmen employed in allied fields. Professionals outside U.S., U.S. Possessions, and Canada: \$25 per year. Nonprofessional domestic rate: \$25 per year. Nonprofessionals outside U.S., U.S. Possessions, and Canada: \$45 per year. Single copy \$5, payable in advance. When filing a change of address, give former as well as new address, zip codes, and include recent address label if possible. Allow two months for change.

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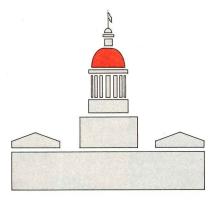
Indexed in Art Index, Architectural Index, Engineering Index. Publication No. 850700. Second-class postage paid at Cleveland, Oh and additional offices. Volume LX, No. 4. Printed in U.S.A. Copyright @ 1979 Penton/IPC.

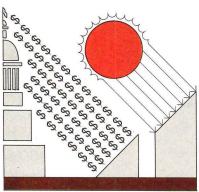


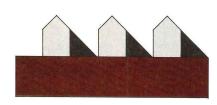


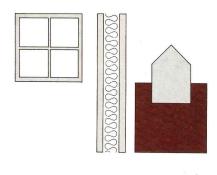


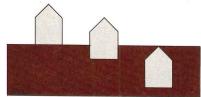
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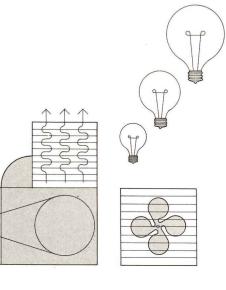
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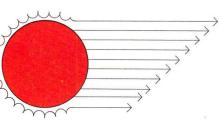
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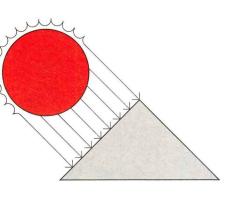
Renowned engineer Fred Dubin answers questions about passive conservation of energy in buildings and the ways in which architects and engineers can reduce inefficiencies.

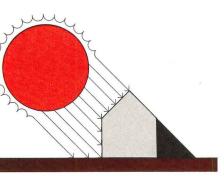
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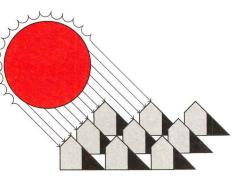
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Cover: Design by Richard Rush

Views

Enduring ferrocement

In your obituary on Pier Luigi Nervi in the News Report (Feb. 1979, p. 35) it was stated, ". marked Nervi's first use of ferrocement, which he invented in the postwar construction period of the mid-1950s.

Although Nervi was the greatest practitioner in the medium, he was not the inventor of ferrocement. That honor belongs to a Frenchman, Joseph Louis Lambot, who patented his "Ferciment" in 1855. Two boats built by Lambot were recovered from the bottom of a pond: one had deteriorated, but is still capable of floating, and the other is in excellent condition

Nervi began his own experiments with ferrocement in 1943, and in 1945 built the 165-ton motor yacht Irene of ferrocement. Also, in the late 1940s his firm built a fishing vessel, the San Rita, and his personal sailing yacht, the Nenelle, of ferrocement.

Although ferrocement has been little used for construction in this country because in its normal mode of fabrication (hand-plastering a stiff mix through the fine interstices of the reinforcement) it is labor-intensive and expensive, the material is ideal for shell construction. Vacuum processes for drawing a wet mortar slurry through the reinforcement and dewatering the membrane have been developed, making ferrocement much less costly. (The writer has a patent on one process.)

In your article on load-bearing masonry in the same issue, mention might have been made of the adaptability of ferrocement to seismic forces, which has not been fully explored. Its flexibility and flexural strength, particularly in shell or monocoque construction, would be a definite advantage in earthquake conditions, as would be its relatively low mass.

Ken Robinson, PE Engineering Conservation Services, Inc. Newark, NJ

Battle of New Orleans continued

The profession of architecture and its chroniclers, critics, teachers, and theorists have on their hands nothing less than a war-an inevitable historical conflict of the sort that happens whenever new and powerful ideas emerge, and not everyone is ready to embrace them and to toss out his old ones. It is the sort of war that is fought mostly in print and in the murderous arenas of university architecture faculties, while clients back the forces of change or of reaction according to their dispositions. If Mr. Lebbeus Woods's assault on Charles Moore and company were from across the field of battle, bearing a flag designed by Herbert Bayer and trumpeting a twelve-tone attack, it could be construed as honorable and in good taste.

But as Mr. Woods is clearly on the side of "the emerging conceptions of historical allusion, architectural symbol, and metaphor, and the decoration of architecture with color and light," his letter concerning the Piazza d'Italia seems more like the Vietnam War custom of "fragging."

Rather than complain about dissension in the ranks or ambitious lieutenants, however, since they will always be found and the metaphor is wearing thin anyhow, I take issue instead with the very idea that Charles Moore's jocularity is somehow doing harm to the cause. Why must revolutions always be so humorless? Is it because of a confusion of the meanings of the word "serious"? Mr. Woods fears that Charles Moore may have "meant to parody . . . the seriousness of architecture and of art itself." (I confess that I am not sure what that is supposed to mean. But I take it to signify that art and architecture are serious, and whatever tries without solemnity to resemble either is suspected of being parody.) The plays of Molière are not "serious" in the sense of earnest tone that those of Racine are, and yet they are serious in that they deal with matters of importance. Nor did they set back the course of drama by their levity. How ill-natured it would be to dismiss Henry Fielding as a "prominent comedian" or "the P.T. Barnum" of 18th-Century literature.

Humor in architecture is certainly rarer and more difficult to achieve than in literature. It is also seldom found in music, to which architecture has often been thermally linked. Yet it does occur in that art as practiced by such agile minds as Mozart, Rossini, Saint-Saëns, Strauss, and Stravinsky. They achieved humor by such means as exaggerated imitation, distorted quotation, and even simple clownlike cavorting. And humor does exist even in respectable architecture. Anyone who has looked closely at the work of Sir Edwin Lutyens will attest to that. So, for that matter, will anyone who has observed the grotesque figures on the walls and roofs of medieval buildings.

I think it is largely a matter of occasion. Humor is quite acceptable in art and literature where it is meant to entertain and where it has satirical intent—where there is danger of something being taken too seriously. It is equally welcome in music meant for light-hearted occasions or just for the occasion of lightening the heart. I hope the warriors of the new architectural cause, Post-Modernism, or Even-More-Modernism, or whatever historians come to call it, will allow that a fountain in a plaza in the country's most strenuously fun-loving city is an appropriate occasion for architecture that evades gravity.

Nicholas Pyle Architect Connecticut

In reaction to Mr. John Steinichen's comment in January's P/A (Views, p. 8) that Charles Moore's St. Joseph's Fountain provoked laughter in every case, I find it refreshing that a work of architecture can instill joviality in a public space; what better captures the spirit of great public spaces of history, especially those of Southern Europe. Gentlemen, relax, or is it still immoral for Americans to enjoy themselves in public, as many of your readers suggest.

Russell C. Jordan Glen Cove, NY

Additional credit

We were delighted to see the News Report (P/A, Nov. 1978, p. 21) covering the Old State House in Hartford, Ct. We are glad some note is being

taken of this noble building, for the structure has been abused on several occasions, and few have been aware of the building and its beauty. When it is renovated, Hartford will gain a new resource. It was a pleasure to read of your sup-

It is curious, however, that no credit was given to any of the consultants on the project. They are as follows: Canton Six and Roger Clarke, architects; Bounds & Griffes, structural engineers; Donovan, Hammick & Erlandson and Burton & Van Houten, mechanical engineers; Zion & Breen, landscape architects.

Roger Clarke Architect

Hartford, Ct.

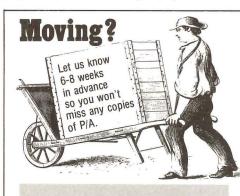
The architectural firm of Charles Kober Associates, which received a P/A citation for the Plaza Pasadena (P/A, Jan. 1979, p. 92), has asked that the credits be amended to include the name of Jon Adams Jerde as director of design-planning, urban design.

Credit corrected

Photos of the Commodore Sloat School (P/A, Feb. 1979, p. 76) credited to Marquis Associates were actually taken by Ron Partridge.

Reversed captions

The Planning Megastructure caption appearing on page 99 of the March issue explains the committee structure appearing on page 98. Construction Industries Critical Path Network on page 98 explains the drawing on page 99.



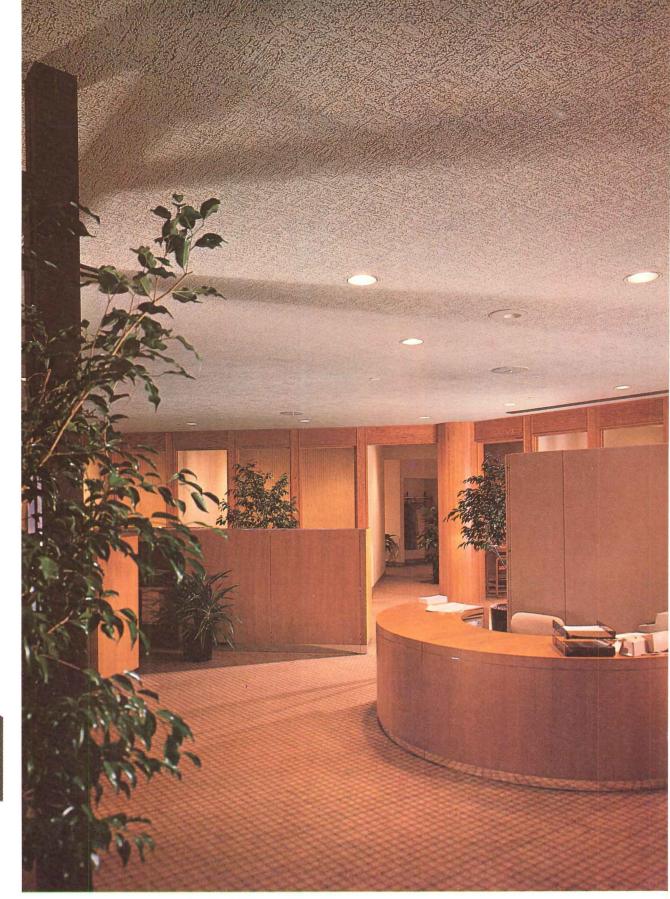
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The energy issue

April 1979

In this late 20th-Century world, we are all beset by "issues," ranging from population pressures, distribution of wealth, equal rights, criminal justice, sexual mores, and disarmament to the role of the arts in society. Some of these are issues that the architectural profession can do something about, and so represent areas in which P/A can make valuable contributions. Right at the top of the list of such issues today is energy conservation, because this is an area in which architects, interior designers, and planners can—indeed must—play major roles. Hence this energy issue you have in hand.

"Issue" is one of those words that have a double meaning for people here at P/A (like "subject," for instance, which means different things to writers, photographers, and photoengravers). As loyal readers know, P/A does not shy away from double meanings; you might even say we have a weakness for them.

So before you delve into this issue—an important one, we hope—on an issue of undeniable importance, a few preliminary words on both subjects:

Issue: a matter of wide public concern Consider for a moment how recently society has turned the matter of energy supply into one of enormous international concern. Those of us in our mid-40s (considered "young" for architects) grew up in a world where air conditioning was encountered only in big-city restaurants and movie palaces; heating was accomplished by shoveling coal into a boiler—and so was a very large portion of travel, powered by steam locomotives. Electric refrigerators were getting common, but the iceman still made his rounds. Even as young adults, architects of my generation might have had to complete their theses (as my class did) with perspiration dripping from their elbows.

The shift to massive energy dependence developed in small, unremarkable

stages. Families acquired cars, then second cars; coal and ice dealers began distributing heating oil and eventually became oil dealers; natural-gas pipelines threaded their way across the countryside. Some of this process generated important news, but mainly in the financial pages, which celebrated the expanding markets for our seemingly inexhaustible resources. Up until the 1950s, the United States was self-sufficient in energy sources. Little wonder that few foresaw the need for concerted action, except for the ultimately futile effort to control developing fuel sources abroad. Of course, nuclear energy was to make the whole issue obsolete in due course, but it hasn't yet, and perhaps it never will.

Now that the crisis is upon us—an international crisis that will last for decades, at least—everybody recognizes it. And we know that the U.S., which consumes more energy per capita than any other nation, will have to make the biggest adjustment. And we haven't yet made a respectable start.

Millions of our citizens consume rivers of gasoline every winter weekend to go to the ski slopes, where they can be exposed to unmitigated winter for a few hours. Then they consume equal amounts of fuel to return to homes, schools, and offices that are maintained at shirtsleeve temperatures all year round.

The economics of energy do operate to some extent, of course. Where I live, I can witness literally acres of turn-of-the-century shingles disappearing under new synthetic siding which is intended to make these charming old energy sieves more manageable. And I read about workers and employment migrating to the Sun Belt, where they contribute further to the congestion of freeways, while housing around the transit stops of Northern cities is abandoned to decay. Meanwhile, new building codes and tax incentives are pressing builders in the Sun Belt to limit the amount of opening in exterior walls, even in areas

where natural ventilation could provide zero-energy comfort for most of the year. Market forces, in a not-so-free economy, operate in curious ways.

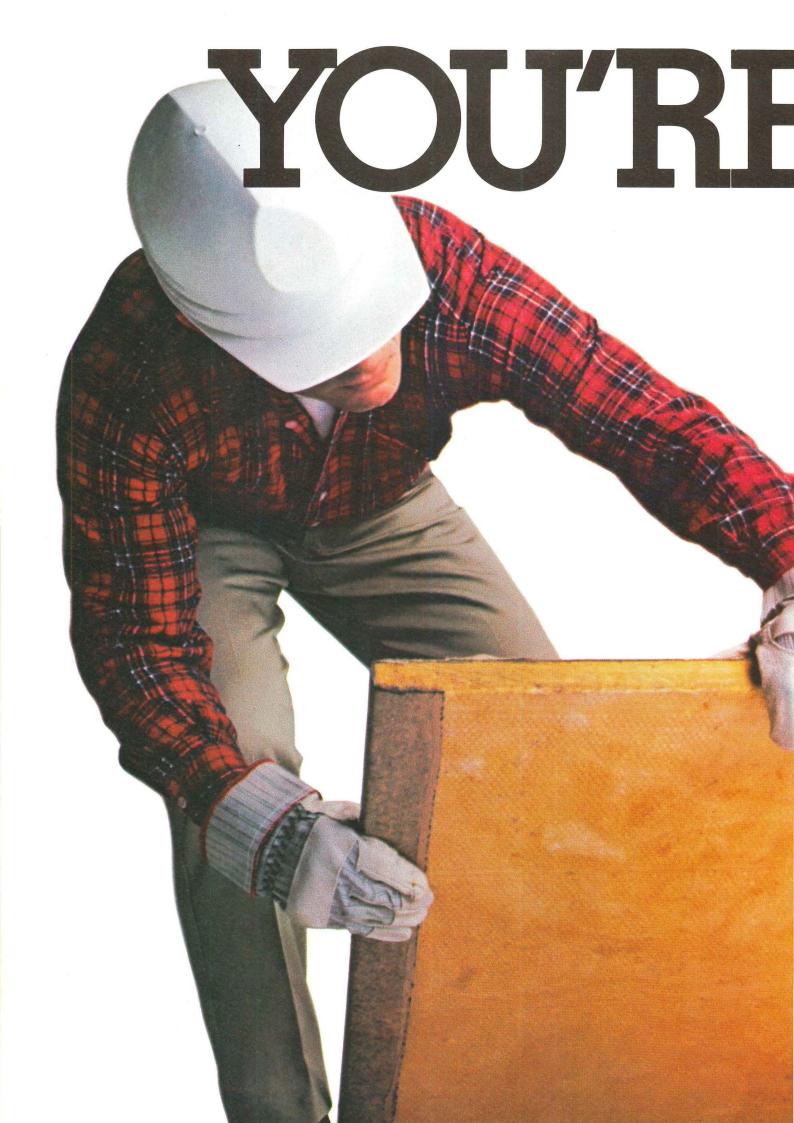
Issue: a single copy of a periodical
This issue of P/A does not look like other recent issues. It has more words and fewer pictures, to an extent that may surprise our own staff when we see it printed and bound. We are not trying to produce a textbook (you will find a guide to those), but there is simply a lot that must be said about energy at this point, and relatively little to show. We know that few of our subscribers are enthusiastic about reading, but we hope that numerous short, varied articles will encourage you to go all the way through—at your own pace.

We have included a number of examples of built work, and a few projects, as case studies in what can be done. We have not emphasized the kind of energyconscious building that has predominated to date—the hand-made, compostproducing rural house. Such demonstration structures have contributed valuable knowledge, but they are not solutions widely applicable in an urbanized, industrialized world. We realize that the examples we have included are imperfect solutions, as well, but they deal for the most part with the range of building programs we face in the real world. (We are not proposing radical socioeconomic reform.)

And we take up the matter of architectural form, not because we are preoccupied with form, but because insulation and hardware are not enough. No building can be made truly energy efficient unless its very form contributes to its performance. Architectural form may be, in fact, the single most effective energy-conserving device.

John Morris Difa





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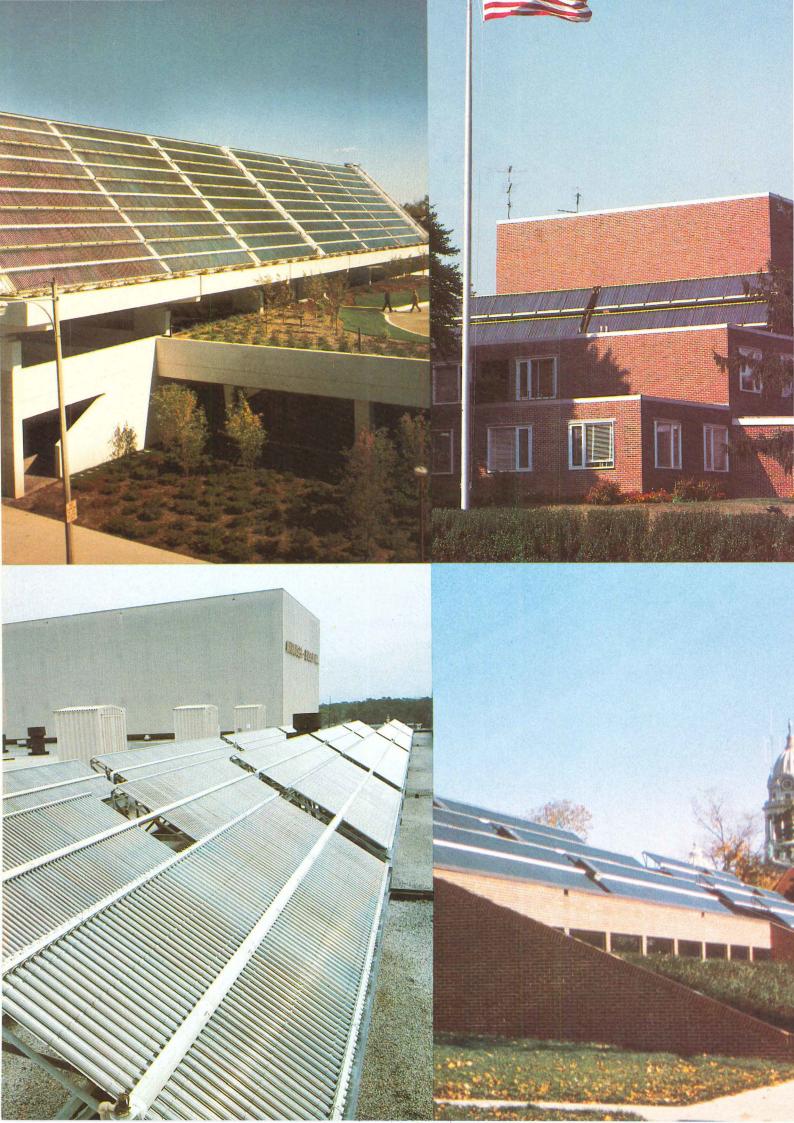
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o Y.K.'s mind, however, one simply does reach the sun without his feet planted ly on the earth.

f we cannot make our collector affordt, then it doesn't really matter how good

nis kind of "dollars and cents" thinking abined with O-l's leading expertise in a technology is responsible for the cessful development and practical applian of SUNPAK™ evacuated tube solar ectors throughout the United States. Middleboro, Massachusetts, for apple, SUNPAK collectors are putting water on tap for busy St. Luke's hospital. Troy-Miami library and the Federal building in Saginaw, Michigan depend SUNPAK systems for hot water, too. To heat. And, in Saginaw's case, air ditioning as well.

Next time you flip open an Anheuser-Busch product, remember: that bottle of beer could have been pasteurized with 150°F water supplied by SUNPAK collectors.

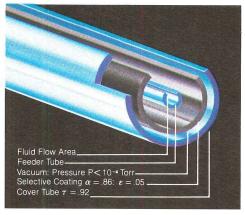
Higher energy output than flat-plate types.

SUNPAK collectors deliver more useful energy than flat-plate collectors. Particularly under "real world" conditions: cold, wind, cloud cover. In fact, efficiencies over four times those of flat-plates are not at all unusual.

The optical characteristics of glass tube and reflector are important, of course. Curved surfaces can better collect the diffuse light as well as direct overhead rays.

Then there's the high performance selective coating and vacuum inside each tube. Together, they minimize heat loss. And the vacuum protects the coating from deterioration as well.

As for the glass itself, it's borosilicate glass. Selected for its strength, low thermal expansion and outstanding heat resistance



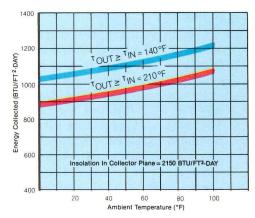
SUNPAK collector tubes absorb and retain energy more efficiently than flat-plate types.

Both coatings and tubes withstand the temperatures encountered during stagnation: 500°F, 600°F and more. And this is not an idle claim.

Extensive life testing proves it.

Freeze and boilout protection.

At the end of the day, all collected energy is drained from the collector tubes through



The outside temperature may be low, but SUNPAK's energy output isn't: close to that achieved at high ambient temperatures.

the insulated manifold. And in a matter of minutes. There's no heat dumping, you see. No energy lost from the working fluid that would otherwise stand in the tubes overnight.

But what's really important to our customers in the Northeast and Great Lakes regions is how this drainability feature protects their collectors from freezing.

And, if there should ever be a power failure, boilout is eliminated the same way.

Simple installation and maintenance.

SUNPAK collectors were designed for installation anywhere, anytime: in new or retrofit structures; for residential, commercial and industrial applications.

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We guarantee our collectors to be everything we say they are. For complete details — and some down-to-earth facts and figures on how our glass "pipeline" can be an important component in your next project — write or call: SUNPAK, Owens-Illinois, Inc., P.O. Box 1035, Toledo, Ohio 43666. (419) 247-9098.

er left: Federal office building; Saginaw, Michigan er right: St. Luke's Hospital; Middleboro, Massachusetts r left: Anheuser-Busch brewery; Jacksonville, Florida r right: Troy-Miami County Public Library; Troy, Ohio

SUNPAK

e build a pipeline to the sun.

Energy Conservation a Bore? Certainly Not to Architects.

Recently, a national public opinion poll indicated that most people in the United States regard energy conservation as one of the five most boring issues of the day. Most architects would disagree, if our own evidence is any barometer.

In 1973, we began publishing a series of energy management Case Studies as four-page advertisements in a number of architectural, engineering and builder/owner magazines. PROGRESSIVE ARCHITECTURE was one of them. The subjects of the Studies were commercial or industrial buildings that had been built from the start with energy conservation as a major design consideration, both architecturally and with regard to HVAC systems.

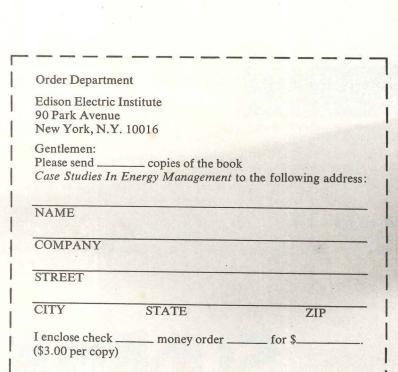
The reader interest in the series—now in its sixth year-has been exceptional. Repeatedly, when readership surveys have been taken of individual magazines in which a Case Study has appeared, the Study has placed first among all the advertisements in the issue. In some cases, the Studies have set all-time readership highs. Clearly, conservation-to the people who worry about saving the nation's diminishing reserves of fossil

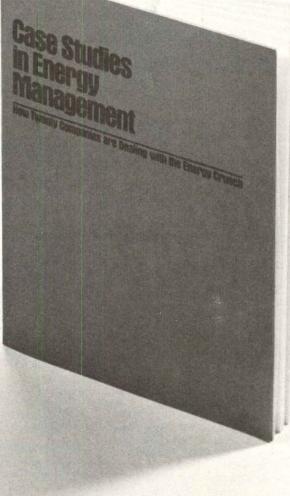
fuels, and about saving money-is not

In response to this designer interest, we have now published twenty of the Studies as a book, Case Studies In Energy Management. The building subjects are of all types and sizes. The one thing they have in common is their creative, imaginative approach to the considerable problem of designing and constructing a building to be as energy efficient as possible. The book sells for \$3.00 and is available now. If you would like a copy, fill in the coupon below and send it to the address indicated. We're

sure you won't be bored. And by the way, if you or your firm have participated in the design and construction—or the retrofitting-of a building whose energy management features might interest other design professionals, send us a note. We will be happy to consider it as a possible future Case Study The Case Study of Greenfield Community College, beginning on the facing page, is the first in a new series dealing with existing buildings that have been retrofitted to incorporate greater energy efficiencies. Additional retrofit Studies will appearin PROGRESSIVE ARCHITECTURE in the months to come.







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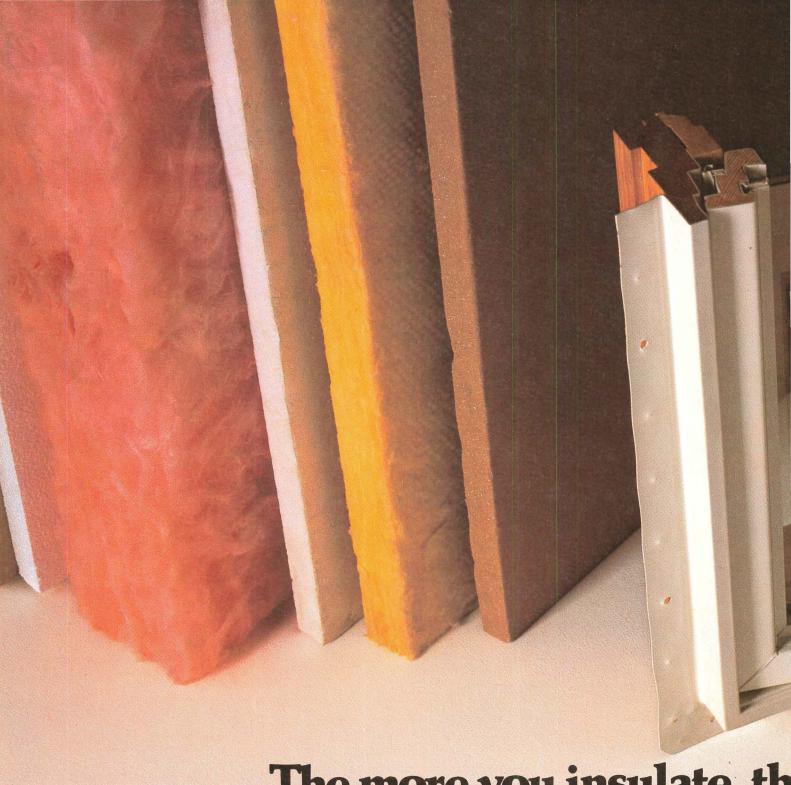
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News report

Energy budgets round two

DOE's second version of the proposed Building Energy Standards (BEPS), entitled the Notice of Proposed Rulemaking, is scheduled for publication in late March. It refines the Advance Notice of Proposed Rulemaking (ANPR), published last November 21, according to the feedback federal officials have gotten from industry and from various impact studies conducted in the interim.

Like the initial ANPR, the new Notice describes the BEPS in terms of energy budgets expressed in Btu per sq ft per year. But several important changes have been made in the way these energy budgets are to be calculated. Originally energy budgets were to be drawn up for 20 categories of buildings in each of seven climatic zones in the U.S. The revised standards are much more climatespecific; at least 37 climatic regions are envisioned. Centered around a metropolitan weather station, these "Standard Metropolitan Statistical Areas" (SMSA) will be modified by conversion factors for other locations.

Functional classifications will also be made more precise. Although the 20 categories originally proposed will remain, the new budgets reflect the fact that many buildings actually include several types of facilities by taking into account the percent of floor space used for each purpose within any one structure.

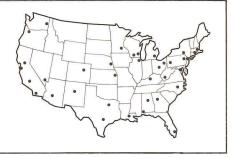
Some of the wide variety of difficulties DOE encountered in setting meaningful energy budgets in the ANPR are resolved in the Notice by these more sensitive classifications. The ANPR did not evaluate energy budgets for assembly buildings, industrial buildings, restaurants, warehouses, multifamily low-rise residential structures, or single-family residences.

SMSA

SPOKANE ALBUQUERQUE DENVER BOSTON HARTFORD NEWARK WASHINGTON BINGHAMPTON ALLENTOWN JOHNSTOWN CHARLESTON

RALFIGH ATLANTA MIAMI MOBILE AKRON LAS VEGAS PHOENIX LOUISVILLE SAN DIEGO MILWAUKEE LOS ANGELES DETROIT BAKERSFIELD

CHICAGO SAN FRANCISCO COLUMBUS SACRAMENTO BIRMINGHAM PORTLAND MINNEAPOLIS MADISON ОМАНА KANSAS CITY DALLAS BATON ROUGE SAN ANTONIO



That November effort found that the category of assembly buildings needed further subdivision. It was difficult to separate process from nonprocess energy use in the industrial buildings group, and the ratio of process to nonprocess energy for both fast-food and full-menu restaurants was extremely high. Data for warehouses showed high and unexplained energy consumption.

DOE recognized that the potential expense of calculating an energy budget would prove a disproportionate burden for the lower-cost building types such as residential and light industrial construction. The ANPR confronted this problem by trying to develop standards for the residential categories based on the National Association of Home Owners Thermal Property Guidelines. However, DOE has now tried an alternative tack in developing budgets for residential construction.

Another major change in the new standards is the reduction of energy budgets for commercial buildings. The cuts come in response to the results of DOE-sponsored studies, which show that, contrary to popular opinion, energy-efficient design does not necessarily mean increased initial costs. An energy-conscious design reduces the size and cost of the HVAC system needed and its component equipment—a fact which previous cost analyses seem to have ignored.

The fundamental defining elements in

the BEPS, outlined below, remain much as they were in November. As DOE did upon publication of the ANPR, they are now soliciting response to the proposed standards, before the rules are finalized.

ANPR basics

- 1 Assembly buildings (those used by more than 50 persons)
- Clinics (structures for outpatient care)
- 3 Colleges and universities
- 4 Hospitals
- 5 Hotels and motels
- 6 Industrial buildings
- 7 Mercantile buildings
- 8 Mobile homes
- 9 Multifamily high-rise residential buildings (over four stories)
- 10 Multifamily low-rise
- 11 Nursing homes
- 12 Office buildings over 4600 sq m
- 13 Office buildings less than 4650 sq m
- 14 Fast-food restaurants
- 15 Other restaurants
- 16 Elementary schools
- 17 Secondary schools
- 18 Single-family attached residences
- 19 Single-family detached residences
- 20 Warehouses, or any temperaturecontrolled structure.

To influence fuel selection by designers, the energy budget figures for all categories, save single-family residences, will be controlled by two other variable factors: RIFs and RUFs.

News report continued from page 25

RUFs

The design energy budgets put forward in the ANPR are correlated to the energy source used by "resource utilization factors" (RUFs). Defined simply:

 $RUF = \frac{\text{resources consumed}}{\text{energy delivered}}$

The ANPR lists the following average national RUF values:

Fuel	RUF		
Oil	1.16		
Gas	1.11		
Electricity	3.04		

The final BEPS will probably use regional RUFs in order to more accurately reflect regional energy costs.

RIFs

The BEPS will also employ "resource impact factors" (RIFs) in order to take social, environmental, and other policy issues into the energy budget calculations.

Architect Wren graces £50 note

The portrait of English architect Sir Christopher Wren has been selected by the Bank of England to adorn the new £50



notes to be issued in 1980. The Bank kept a shut upper lip on the list of competitors for the highest denomination of British currency ever issued, but a Guardian report had it that "the short list could include" Lord Nelson, Sir Francis Drake, the engineer Isambard Kingdom Brunel, and Sir Edward Elgar. Feeble feminist contenders, according to the report, were the warrior queen Boadicea and suffragist Emmeline Pankhurst. The Bank is one of the few buildings of note in London whose design Wren had nothing to do with. The present premises in Threadneedle St. were designed in 1788 by Sir John Soane (1753-1837), although subsequent modifications have destroyed Soane's work.

Passive solar aims at homebuilders

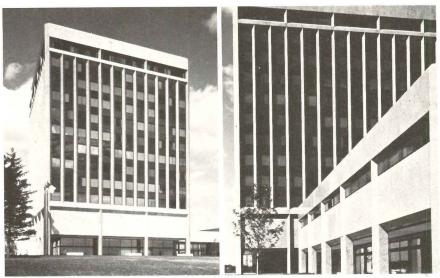
'The prime target of the current HUD and DOE policy with regard to passive solar installations in residential construction is the spec builder." As Douglas Kelbaugh stated succinctly at the recent National Passive Solar Conference in San Jose, Ca, the government clearly wants to take advantage of the mechanisms of the marketplace in increasing the use of residential passive solar systems. Such a policy, designed to implement a solar variable in the lowest common denominator of "architecture" that spec builders construct, is not conducive to innovative design, since designing for the tract-builder market means designing for mass appeal and for the "bottom line." Moreover, it is a policy which seems to be rather ineffectual.

Builders are understandably opposed to any changes in housing design and construction which would mean higher initial costs and/or potentially lower profits. It's not too surprising that the building community has resisted solar in general and passive in particular. (The slightly greater acceptance of active systems has been mainly due to the public relations efforts of manufacturers of solar collectors.) And at the most basic level of energy-conscious design, builders have constituted one of the strongest lobbies against the imposition of the proposed DOE BEPs.

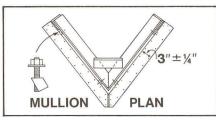
The results of the recent HUD Passive [News report continued on page 31]

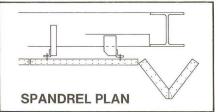
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Architect: Graham Anderson Probst & White, Chicago, IL





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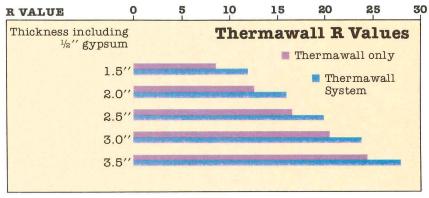
685-3621, or write to the address below.

Putting up Rmax Thermawall means tearing down a few old ideas.

Conventionally, commercial wall insulation and finishing has consisted of three things. Studs, batt insulation and gypsum board. At Rmax, we have an approach that is slightly unconventional.

And simply fantastic.
Rmax Thermawall. A
rigid urethane core permanently bonded to gypsum
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Together, it combines the most efficient insulator available with a practical, time saving method of installing finished drywall. Resulting in unsurpassed savings. Both in installation costs and future energy bills.



Our unique Thermawall Fastening System (patent pending) eliminates common studs and batt insulation. It's thinner than conventional stud walls, so you gain floor space. And at the same time solve an old problem of in-

creasing square footage for tenants.

We're helping solve a new problem, too.

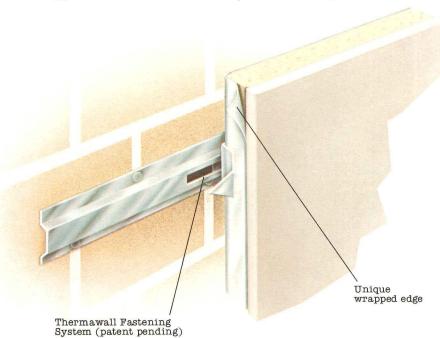
Rmax Thermawall is perfect for insulating residential cathedral ceilings. It's efficient enough to achieve maximum insulation value when used with standard 2 x 6 roof rafters and R19 batts. Which eliminates the need to change construction techniques. And in turn, saves money.

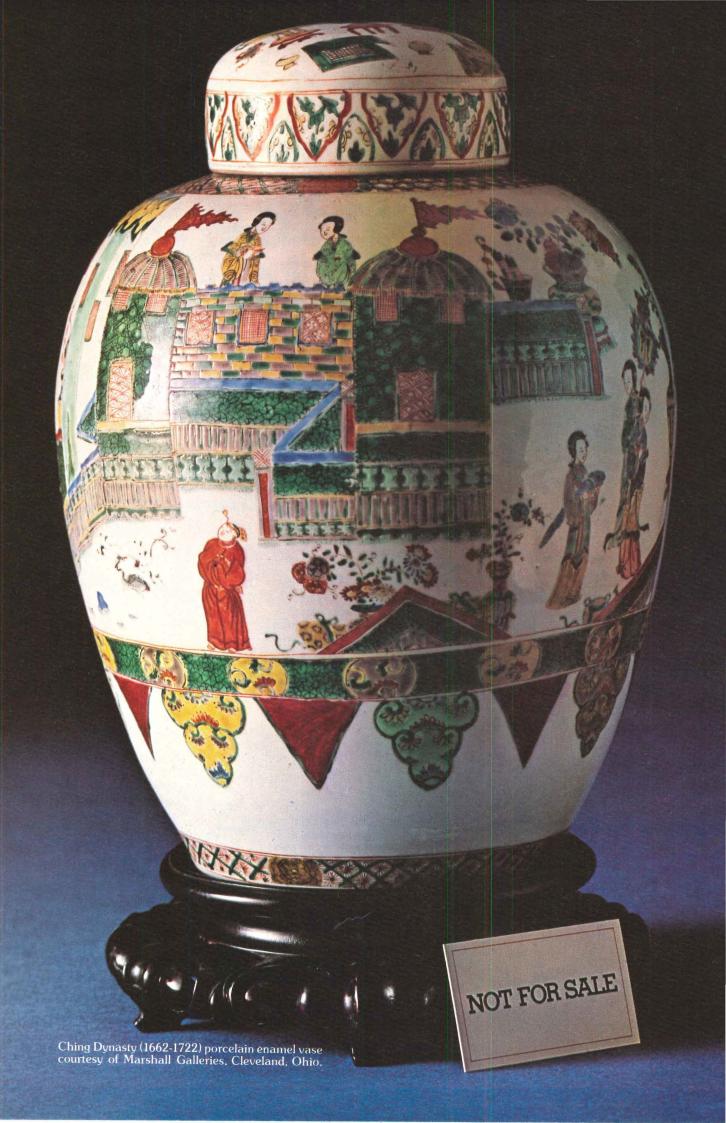
Call Rmax about an unconventional look at your insulation needs. By tearing down a few old ideas, we can help you build in more value.

Thermawall by Rmax

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Rmax also manufactures a complete line of rigid urethane insulation for commercial roofing and sheathing requirements.





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Even though it's centuries old, the colors are exciting.

That's durability. And that's because it's porcelain enamel.

At AllianceWall, we adapted the idea to help you make buildings beautiful and to keep them looking that way. Permanently. Inside and out.

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They're also inherently durable. The porcelain is fused to steel at such high temperatures that it actually becomes part of the metal. So they resist most everything—fire, fading, stains, even scratches. And you can imagine the maintenance. Or rather, the lack of it.

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There's a wide range of matte and semi-gloss colors available in smooth finish. And with our Wolverine line, you can get into

shapes, patterns, textures and graphics that are limited only by your imagination.

AllianceWall porcelain enamel panels.

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as a base and go from there?

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New Mexico-Bank, Albuquerque, New Mexico Architect: W. E. Kruger & Associates

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Also, it offers excellent dimensional stability, weatherability, heat resistance to 270°F, a UL continuous use rating of 115°C, UL 94 flammability ratings* of V-0 and V-2, and outstanding melt strength for intricate shapes.

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Do it today, and you'll be in fine shape tomorrow.

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News report continued from page 26

Solar Residential Competition, soon to be published by HUD, demonstrate that here again builders and developers failed to respond to HUD's advances. The competition was designed so as to favor entries from homebuilders: among other stipulations, the project had to have a committed client. However, the majority of the entries turned out to be from independent architects challenged by passive to find unique solutions, and a large number of the \$5000 awards accordingly went to projects rather more exciting than those HUD probably envisioned.

The competition, which Omi Walden, DOE secretary for Solar Applications, optimistically described as "the first step in accelerating the commercialization of passive solar designs . . ." resulted in 242 awards, announced last December 20. Of these, 145 were awards of \$5000 apiece for new designs, 17 of \$2000 apiece for retrofit designs, and 80 for \$7000 apiece were to builders willing to construct a single model of a winning submission. (An additional \$2000 was given for each example of a model—up to 4—constructed.) Almost a third of the winning projects came from three states: Colorado, (33) California (18) and New Mexico. But only 14, 5, and 2 firms in these respective states were willing to build models.

Exhibitions of architectural import

Transformations in Modern Architecture: 1959–1979 Feb. 23–April 24 Museum of Modern Art, NY Dec. 19, 1979–Jan. 27, 1980 The Cleveland Museum of Art Feb. 23–April 27, 1980 The Art Gallery of Ontario, Toronto.

Had MOMA wanted to insult the art and profession of architecture it couldn't have done more. "Transformations," organized by Arthur Drexler, director of the Dept. of Architecture and Design, is the Museum's latest and long-awaited comment on recent architecture. The Olympian view set forth: since Modernism, architecture has occurred like the stages of an infection, more or less independently of architects' intentions.

Modern architecture, according to Drexler, can be reduced to three vast "isms": "Cubism and Expressionism," "Structuralism," and "Regionalism and Vernacular." In rather arbitrary selection of the 400-plus projects included, the show does not seem to recognize that any or all of these styles can be executed well or



From MOMA melange: a) Kahn's Assembly Bldgs., Dacca; b) Roche-Dinkeloo's corporation hdqtrs.



badly. Worse yet, the manner in which the works chosen are arranged denies the value of artistic selection in architecture: the reasons for which an architect selects a style and the way in which he adapts it to his purpose—factors which mean more to the design than the mere choice of mode.

In a tomblike installation, blown-up snapshots crowd around the walls, juxtaposed so as to stress the most facile visual connections between buildings. Almost every building is represented by only a single photo, a treatment which denies the importance of a building's color, texture, or shape, and masks the quality of the total design. Only exempted from this penance are a series of glass-box buildings; back-lit color transparencies of these are set apart in a darkened inner chamber.

When so many buildings in the show use color to far better purpose, there does not appear to be any aesthetic justification for giving the lushness of color to glass boxes alone. It is all too easy to infer a connection between this privileged treatment and support for the show by PPG Industries Foundation (along with the Graham Foundation), though PPG asserts the funds were not specifically earmarked.

Totally out of physical or philosophical context, the buildings are grouped in categories derived not from the buildings themselves, but from the superficial resemblances created by the photographs. As one architect commented, baffled by the positioning of Arata Isozaki's small, elegant Fujimi Country Club (1973) adjacent to a sprawling, Roche-Dinkeloo project for a gawky corporate headquarters: "I don't understand the categories; good and bad design, totally different functional and aesthetic programs are all jumbled together."

Carlo Scarpa's lovely 1957 Olivetti showroom in Venice, a sensitive coordina-

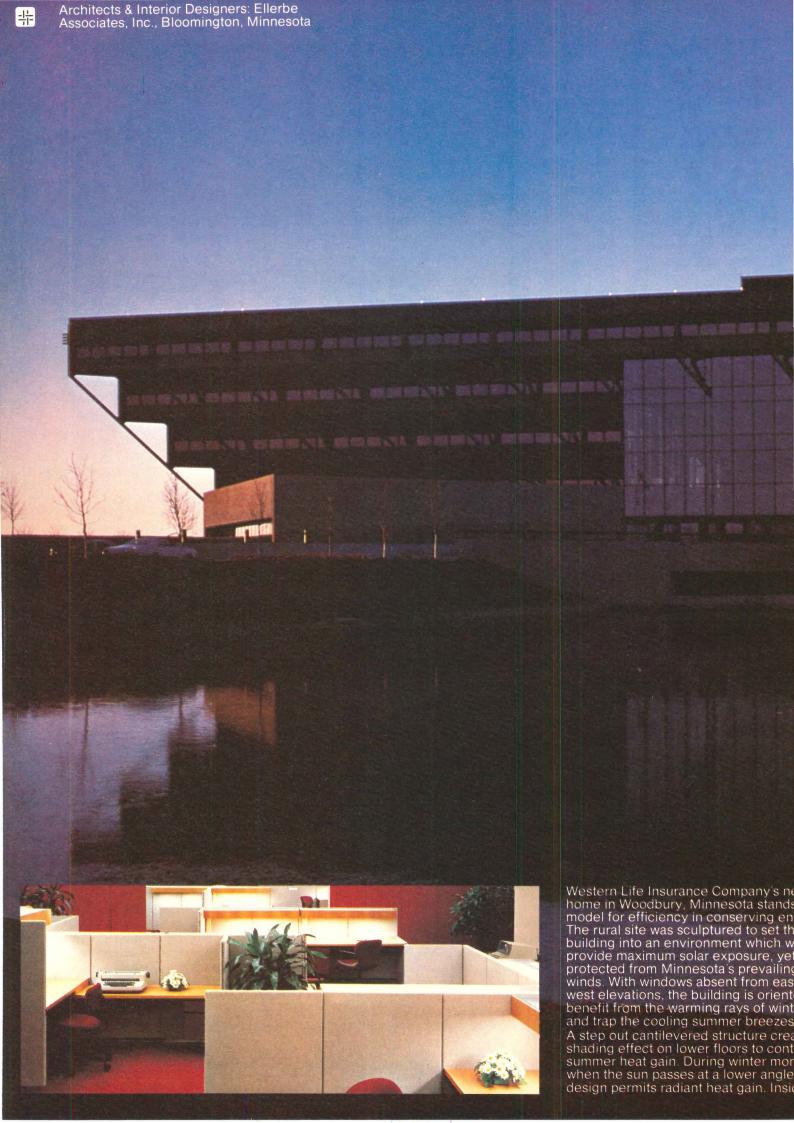
tion of older fragments and new elements into a stunning interplay of line and texture, is lumped under the "historical" heading with AT&T's hodgepodge of inapropos references. Robert Stern's 1973 "Lang House" and Venturi and Rauch's 1977 "Tucker House" are directly compared to custom-built schlock.

The descriptions seem insensitive to buildings' intents and effects: SOM's 1969 Bank of America World Headquarters is "vernacular" because its "prowlike bay windows reflect a popular San Francisco idiom." As anyone who has ever seen a photo of the building in its urban setting can tell, the dark, aggressive tower is a visual attack on the light-colored, simpler forms of downtown San Fancisco.

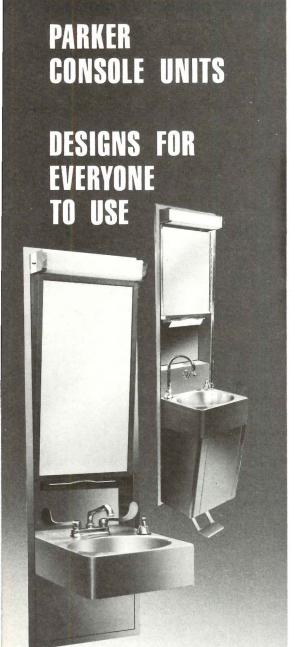
Ironically, the most intriguing section of all is a small roomful of odd details that didn't look enough like anything else to justify categorizing. Some of these, and a few more fortunate projects like Ricardo Bofill's 1976 "Monument to Catalonia," a Gaudíesque brick temple whose twisted columns express Catalonia's hopes and desolation, are so photographed as to be arrestingly beautiful, diamonds in the visual dust to which most of the projects, irrespective of their real merit, are brought.

By homogenizing the best and the worst, the show gives the impression that there has been little designed or built in the last twenty years that is unique, innovative, outstanding. Indeed, in introducing the show, Drexler abdicates the inherent responsibility of the exhibit, to comment on developments in the art, by denying that there have been any of significance: "What has changed is not so much architecture as the way we see it and view it."

We who? Architects do not view their work in the superficial, general, and aesthetically sloppy manner in which Drexler [News report continued on page 34]







Parker offers a large selection of console units, to meet the specific needs of the people who use them in each of a wide variety of healthcare settings. The stainless steel units shown here both provide complete washing facilities, yet each is designed for a different application. The sanitary foot-operated model is ideal for the use of doctors and nurses. The other, with a special protruding sink and tilted mirror, is intended for the easy use of patients confined to wheelchairs. When specifying a console unit, look to Parker for a unit that's perfect for the people who'll be using it.

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presents it. That a respected museum can invite the public to do so is, as every knowledgeable viewer has commented, profoundly depressing.

Portraying Modern architecture as a contagion of forms, *Transformations* seems to have intentionally forgotten that architecture is not a disease, but is an art, and that the creation and appreciation of any art depends upon fine distinctions.



Hans Scharoun, "Building with Wings". 1939

Visionary Architecture
Drawing Center, New York
Jan. 20–May 5
Travel plans to be announced.

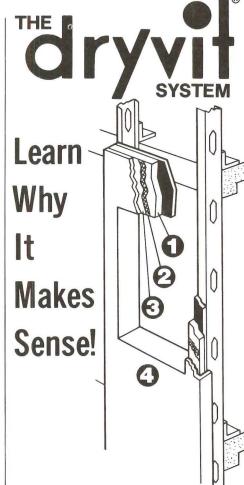
The gap between an architect's conception and its realization as architecture is uncannily wide. Architects respond to this in a number of ways—they deny the importance of unrealized ideas, they construct a post facto philosophy around their built work, they write manifestoes, or they sketch visions. Architectural historians tend to believe that ideas make history, and therefore they are interested in the history of architects' ideas.

Professor George Collins of Columbia University has to be one of America's top modern architectural historians. This exhibit he directed, which under the auspices of Smithsonian Institution Traveling Exhibition Service will travel to twelve cities over the next two years, expresses his scholarly perspective.

"Visionary Architecture" consists of some 130 drawings representing about 30 architects and dated 1900–1970.

Many of the drawings in the show are rare works of art and documents of architectural history. It's a thrill to see Sant' Elia's monumental Electric Power Station, for example. Like browsing at a rare book sale, the show offers heterogeneous, unexpected, and erudite pleasures.

But the exhibit lacks focus and definition. Widely varying levels of conception are taken as "visionary." Le Corbusier is represented by his illustrations for a lecture, Frank Lloyd Wright by some rather [News report continued on page 36]



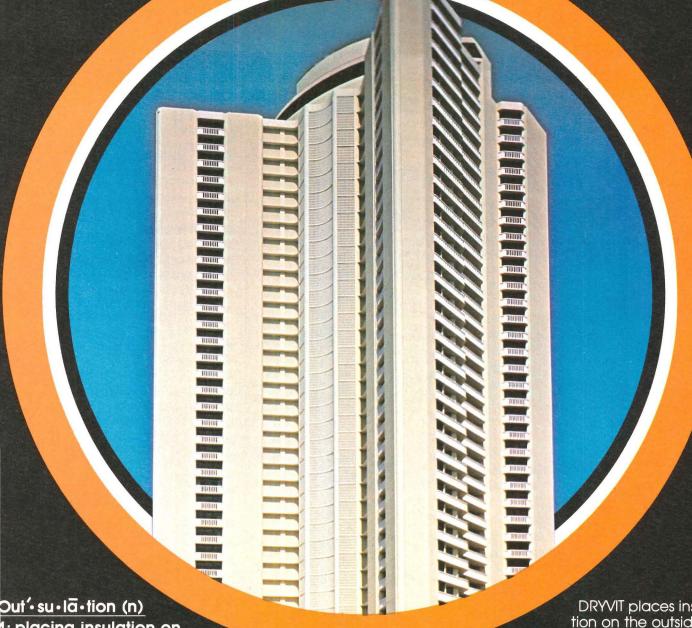
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News report continued from page 34

pragmatic designs for residences. These are hardly representative visions of these masters, if they can be called visions at all. Certainly they have little in common with the exhibited work of Peter Cook, in which the drawing is the end in itself. Collins has taken "paper architecture" as synonymous with "visionary" and has included in the former category all works on paper by architects, save working drawings.

The wide range makes for facility and fragmentation. The small, unconnected, and highly particular groups of drawings, lacking context or clear criteria for selection, fail to make any coherent statement about the architectural visions of our century. In fact, "Visionary Architecture" indicates that the precepts of architects for whom drawings are not the ultimate medium are better grasped in the interface between their paper and their built architecture, where the idea hardens into a form with more dimensions.

AIA Honor Awards a few surprises

"This is not a cutting edge competition!" admitted William Caudill of CRS, chairman of the 1979 AIA Honor Awards jury for new buildings, yet there were indications of a broadening of outlook. Up to now, this program has not honored a single work that could be construed as Post-Modern; the 1977 jury acknowledged the emergence of "differing points of view" in their report, but could identify them only as "directions for the future." This year symbolism, allusion, and ornament finally found acceptance, embodied in the MLTW's Pembroke Dorms (P/A First Award, 1970).

The nine "new" category winners (out of 300 entries) included several large, almost predictable choices and one 18-ft-sq Thoreau-esque beach cabin.

Again this year, the separate jury for "extended use" work was more generousselecting 6 out of 55 entries—and less hidebound. (In this category, Venturi & Rauch's Franklin Court was chosen in 1977.) One of this year's winners is Michael Graves's Gunwyn Offices—an adventurous AIA choice, even though it was completed back in 1973.

Current winners:

The Architects Collaborative Inc., Cambridge, Ma, for Johns-Manville World Headquarters, Jefferson County, Co.

Arne Bystrom, Seattle, Wa, for Bystrom Family Beach Cabin, Pacific Coast, Wa.

MLTW/Moore, Lyndon, Turnbull, Inc., Lyndon Associates, Inc., Cambridge, Ma, for Pembroke Dormitories, Brown University, Providence, RI (P/A, Feb. 1976, p. 47).

Morgan & Lindstrom Architects, Bainbridge, Wa, for Lindstrom Residence, Bainbridge Island, Wa.

C.F. Murphy Associates, Chicago, II, for Angela Athletic Facility, St. Mary's College, Notre Dame, In (P/A, Aug. 1978, p. 58).

Sert, Jackson & Associates, Inc., Cambridge, Ma, for Joan Miró Foundation, Barcelona, Spain, and Undergraduate Science Center, Harvard University, Cambridge, Ma.

Skidmore, Owings & Merrill, Portland, Or, for Portland Transit Mall, Portland, Or. Hugh Stubbins & Associates, Inc., Cambridge, Ma, for Citicorp Center, New York. (P/A, Dec. 1978, p. 34 and p. 54).

Extended use winners:

Anderson Notter Finegold Inc., Boston, Ma, for Mechanics Hall, Worcester, Ma.

Michael Graves, Princeton, NJ, for Gunwyn Ventures, Princeton, NJ (P/A, Feb. 1973, p. 82)

Hardy Holzman Pfeiffer Associates, NY, for St. Louis Art Museum, St. Louis, Mo. Holabird & Root Architects/Engineers/

Planners, Chicago, II, for Chicago Public Library & Cultural Center, Chicago, II. Louis & Henry, Inc., Louisville, Ky, for Louisville Museum of Natural History and

Science, Louisville (P/A, May 1978, p. 82). Herbert S. Newman Assoc., AIA, New

Haven, Ct, for Center for American Arts, Yale University, New Haven, Ct. [JMD] [News report continued on page 40]



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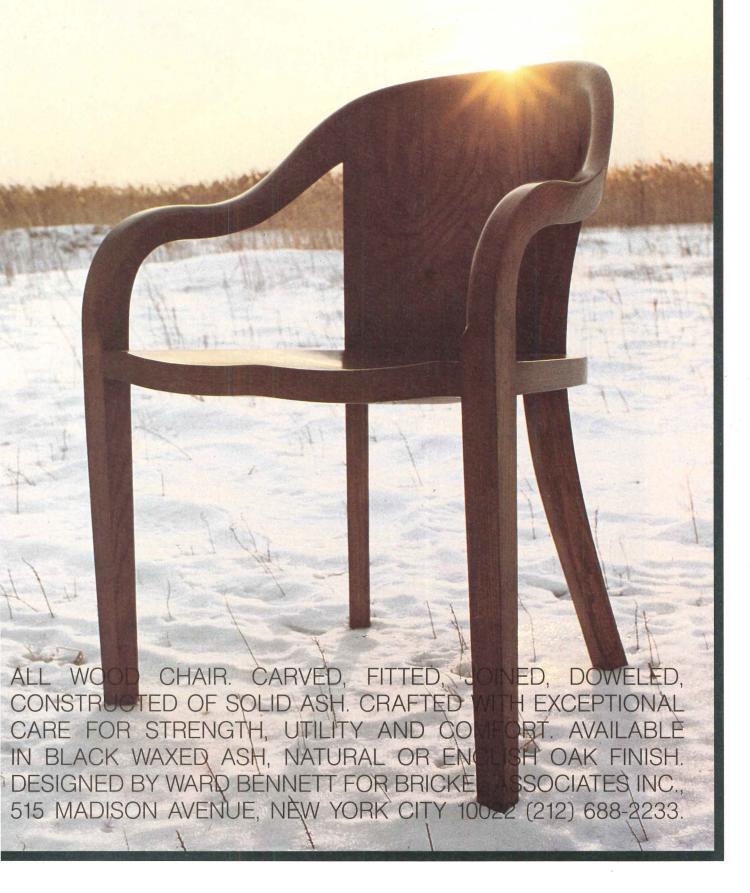
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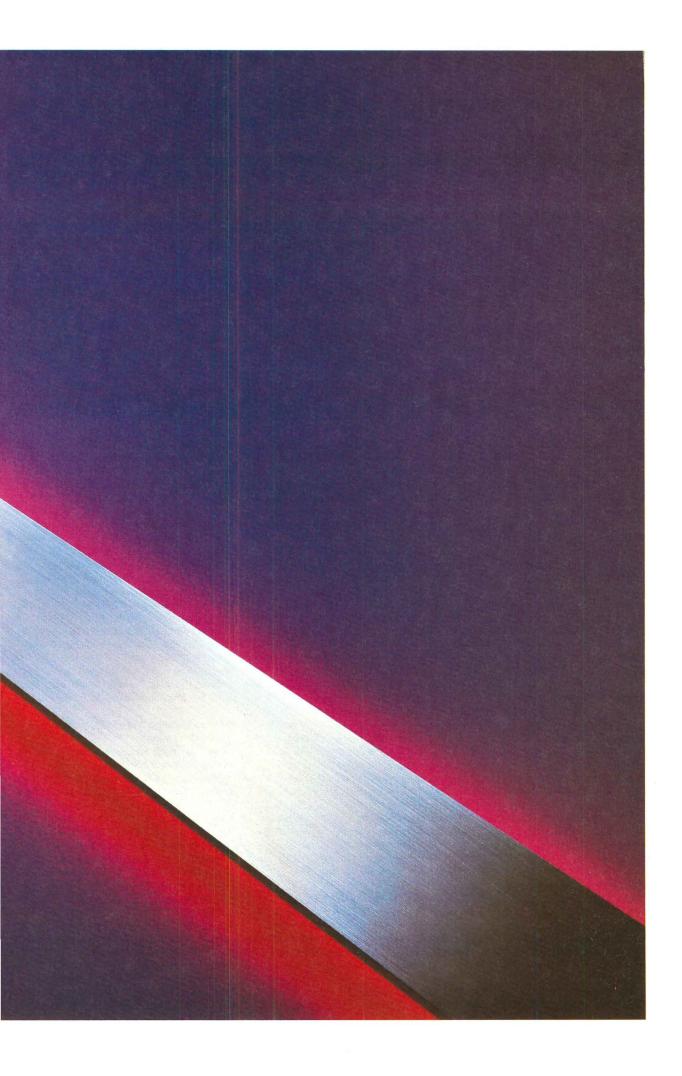
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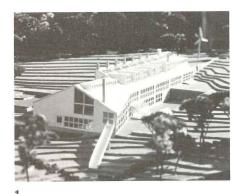
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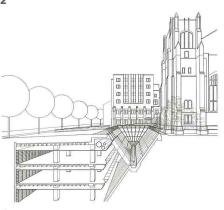


1 Resident Center for Environmental Studies and Activities, Milford, Pa. Designed by Environment Partnership of Princeton, NJ, this dormitory and classroom building for a nature center incorporates four types of passive solar heating and cooling, several of which were pioneered by the architect in charge, Douglas Kelbaugh. An externally heated Trombe wall, direct-gain with water drums, an attached mass-wall greenhouse, and a passively heated storage tank to preheat domestic hot water will provide about 75 percent of the building's heating needs. Water consumption and septic system will be cut in half by the 15 composting toilets, and the two windmills will pump water and provide auxiliary electricity. The concrete building, stylistically reminiscent of local farmhouses, is cut into a slope falling to the west. The 16,000-sq-ft project with its adjacent related landscaping should cost \$1.2 million; completion is scheduled for summer 1980. The residential center is the first phase of a public nature center planned for the 1600-acre wilderness site by the client, Milford Reservation Inc., a nonprofit organization. A complex housing classrooms and exhibit areas is to follow.

2 Santa Rosa Creek Cooperative, Santa Rosa, Ca. Architects Jacobson/Silverstein, of Berkeley with Peter Calthorpe have designed a compact housing cooperative which utilizes participant design techniques and passive solar strategies. At a density of 20 units/acre, the scheme includes a community meeting hall, 25 units of new construction, and the remodeling of older houses on the site. The new housing is organized into three separate buildings, each with a central atrium-greenhouse, covered by a system of operable fans and vents, which serves as the common solar collector for the surrounding seven or eight units. Each unit has windows opening directly into the atrium and to the exterior for cross ventilation. Excess heat collected in the atrium is blown through concrete floors for storage and radiant heat distribution within each unit. Solar collectors on the roof provide energy for hot water. Completion of the \$1-million project is scheduled for mid-1980.

3 Student recreation facility of Georgetown University, Washington, DC. Designed by Daniel F. Tully Associates, Inc. of Melrose, Ma,





this innovative gymnasium uses a patented engineering technique to bury a 142,000-sq-ft athletic building under a football field and track, a design which saves real estate and energy simultaneously. Tully and Creative Building Systems, also of Melrose, were selected to design the new gym on the site of the existing football field and rebuild the field on the roof. The \$7million project integrates a 5-in. "hyperbolic paraboloid" shell with a concrete diaphragm deck to span 130-ft bays with minimal deflections. "By marrying a multicurved with a horizontal surface, the strength of the structure is enhanced four or five times," Tully explains. The facility is made up of 18 units, 11 of which have the maximum 130-ft span that the steel frame system supporting the deck allows. (Tully is now working on a precast concrete structural system which may make possible 150-ft spans.) The estimated \$500,000 cost of placing the building underground was more than compensated for in real estate costs saved, but the building's energy-conserving features will also reduce annual operating costs to less than one-third of those for a comparable conventional building. "The thermal inertia from the underground placement will alone reduce energy consumption by 20 percent annually," says Tully. "But where we're really saving is by recycling the heat in the exhaust air from the pool and toilets through the use of heat recovery wheels." Construction of the facility began in August 1977 and should be completed in May 1979.

4 Law Library, University of Michigan, Ann Arbor. Architect Gunnar Birkerts' design for an L-shaped addition to the self-contained Law School block integrates the new library with the existing pseudo-Gothic complex while using daylighting and energy-conserving features. The underground design solution wraps the corner of the old library and connects directly to the main reading room, but its grass-covered roof will mask the intrusion of the earlier build-



3

ings. A V-shaped trough runs moatlike around the older structure; one glassed face of it is to serve as a skylight to the three traylike floors of the 50-ft-deep underground addition. The location and configuration called for unusual engineering systems to counteract unbalanced earth stresses and to retain the earth and the neighboring buildings. The solution consisted of an augured cast-in-place piling system, reinforced with steel wide-flange sections and prestressed tiebacks, whose stress levels are carefully monitored. It is estimated that the below-grade design, and the daylighting systems incorporated, will conserve 20 percent in heating energy costs over a similar, abovegrade structure. The \$7.5 million new library contains 77,500 gross sq ft of space, 62,500 of which will be completely finished by mid-1981; another 15,000 sq ft—5000 sq ft on each floor —will be left as undeveloped expansion space.

5 Office Building, Toronto, Canada. A proposed office tower in downtown Toronto, designed by Annau Architects and currently under review by the client, uses active solar systems in a contextually sensitive design. The south face of the 22-story building slopes up from the adjoining two-story older building in four stepbacks echoed in four setbacks along the east façade. The sheer north face confronts a highrise tower across the street. The top two-anda-half south-facing roofs are faced with liquidtype solar collectors to provide space and hot water heating, while a solar cooling system is planned for the lower one-and-a-half. Solar-heat storage tanks are located within the building envelope in the basement—a design which a recent Canadian study has found results in substantially less heat loss than storage tanks set in the ground. The 232,000-sq-ft tower has an estimated cost of Can.\$12 million; the payback period for the 8 percent additional initial costs of the solar features is estimated at 10 years. [News report continued on page 45]







ntiac Silverdome Left: LaVerne College

Right: Duval County Service Center

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Eastland Mall, Charlotte, N.C. Little and Associates, Architects.

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But how do you justify the initial of ceramic tile in logical, dollars-and-ce

creative person to eramic Tile:



Museum of Natural History & Science, Louisville, Ky. Louis & Henry, Inc., Architects.

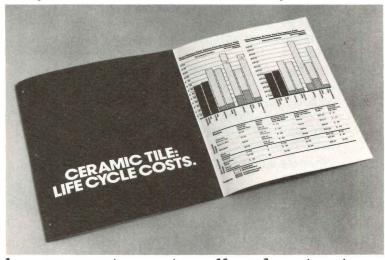
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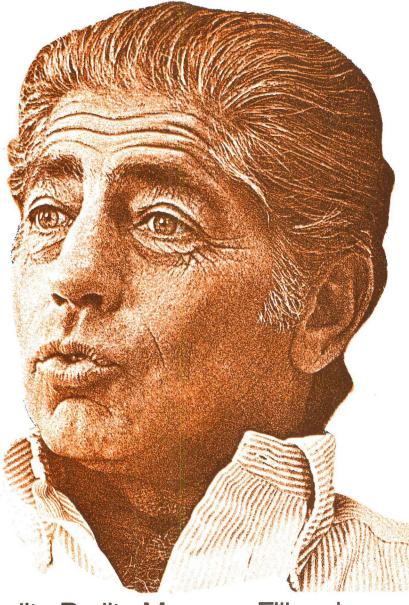
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News report continued from page 40

In perspective

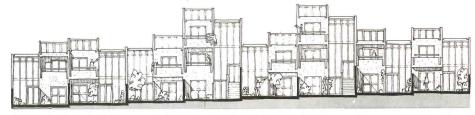
The solar shadow: A discussion of issues eclipsed

Every good presentation on solar energy seems to start with some slides of a New Mexico cliff dwelling, such as Mesa Verde. The normal discussion centers on the orientation, shading, solar gain, and sometimes defense aspects of the dwelling. What is not mentioned is the coherence of the community, the density, the shared spaces, and the integration of all daily activities. Only after years of U.S. domination does one find the pueblos beginning to spread over larger areas, losing their center and common ground. The lessons to be learned from the pueblo are more than solar thermodynamics. However, solar energy is becoming a panacea for our energy ills, the answer of soft technology. There is now a danger of this bright technology casting what is perhaps a long shadow over the broader issues of the patterns of growth and development and their effects on resources, the environment, and people's lives. The form and density of housing, the land use patterns, and the resulting transportation systems have a much greater potential for energy savings than any solar applications. If our community scale development is rational, residential solar applications need provide little more than marginal improvements.

A building is tied to energy use not only by its structural and mechanical design, but by its connections to employment areas, community services, and by its implicit infrastructure: the amount of pipes, roads, and utility wires it demands. Since the Second World War the predominant symbols of our progress have been the growth of suburbia, freeways, and highrise office buildings. These developments create an infrastructure and a development pattern which must be rethought at the same time that alternate energy solutions are developed. If they are not, there is a danger that solar and other alternate energy sources may become a mechanism to perpetuate these inefficient patterns rather than a means to a more environmentally sound culture.

The present emphasis of solar development assumes the continuing expansion of suburbia. The passive home designs, the active systems modeled at the universities, and a good part of the federal research and demonstration programs are focused on the single-family dwelling.

It has been estimated that if all the single-family homes built between now and 1990 employ passive solar heating and cooling systems, as much oil will be



An example of a townhouse adapted for passive solar heating is a low-cost farm-worker housing project planned in Watsonville, Ca. Cement-block common walls provide thermal mass, sound insulation and fire safety. This passive solar system needs about one-half the greenhouse area and half the thermal mass that a passive single-family home in the same climate would require. "Techo." Developers: Environmental Community Housing Organization. Architects: Van der Ryn, Calthorpe and Ptrs.

saved as is expected to be recovered from the Alaskan North Slope. However, if the increased number of automobile trips resulting from this sprawling growth between now and 1990 were figured into a net energy analysis, the savings from passive solar would be greatly outweighed.

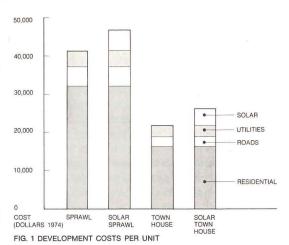
Fuel for transit is not the only resource demanded in large quantity by single-family suburban development. Land is another. Most common zoning restrictions and development patterns require the single-family dwelling to "float" on its site surrounded by minimum setbacks from the street and neighboring lots.

Beyond land and transit, the potential energy savings from solar heating and cooling of buildings is greatly overestimated because of the inherent inefficiency of our most common housing forms. Without solar and with a more severe climate, Sweden employs approximately 50 percent less per capita energy use for residential heating than that used in the U.S. Building scale, shared walls and floors, infrastructure, district heating, and better insulation could greatly reduce the energy demands of new housing.

The cost of sprawl

A thorough investigation of the resource and environmental cost of new developments was made in 1975 by the Real Estate Research Corporation. The study, "The Costs of Sprawl," assesses six model community types most likely to occur on undeveloped land adjacent to existing metropolitan areas. In the last decade, 70 percent of the growth in this country occurred in such areas. Each community type used in the study contains the same amount of land—6000 acres—has 10,000 dwelling units, and a population of 33,000. The communities are made up of singlefamily detached homes, clustered singlefamily homes, townhouses, two-story walk-up apartments, six-story apartments, and a combination of the above.

The resulting land use diagrams of the housing types showed a 200 percent difference in the amount of land consumed between the higher- and lower-density housing projects. The comparison yields an identical contrast with respect to capital



400

400

300

100

SPRAWL SOLAR TOWN SOLAR TOWN SOLAR TOWN HOUSE FROWN HOUSE
ENERGY CONSUMED PER UNIT
FIG. 2 COSTS OF SPRAWL MODEL

costs of construction, which reflect resources consumed in building and to some degree the amount of pollution produced in the process (Fig. 1). The energy consumption of each housing scheme is determined primarily by the amount of automobile use within the development area, combined with the residential heating and cooling consumption. Even though the study doesn't include the effects of the development's location with respect to job or town centers, the resulting energy consumption difference between the highand low-density models is nearly 100 percent (Fig. 2). In all the issues contrasted. high-density planned developments had a more benign environmental impact than low density sprawl.

Let us assume that a solar installation, either passive or active, can reduce the energy consumption of each dwelling for

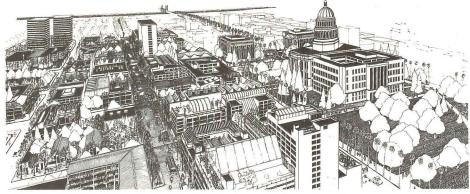
heating, cooling, and hot water by 50 percent on a national average. (Although solar can provide up to 70 percent of a building's needs, the cost effectiveness of such high performance systems falls off radically.) This 50 percent reduction would produce a new graph (Fig. 2) in which the average energy consumption for each solar single-family dwelling would still exceed the consumption of the nonsolar climatically unresponsive higher density planned dwelling by 30 percent! This solar application would not significantly affect the water and pollution, transit, or land use comparisons. It would, however, raise the capital costs for the low-density model significantly, fueling the argument that only a financial elite can afford such an environmentally responsive future.

A more concrete example of these issues is given by a well-designed passive solar home located on the top of the highest ridge in the California Coastal mountain range. Just down the ridge is another house under construction of a more standard variety. Comparison of the energy and environmental impacts of the two houses shows that the real differences are small. Both consume beautiful open space located near metropolitan areas which should be preserved for public use. They will probably produce the same amount of solid waste and consume the same amount of materials and energy in construction. Both demand an equally irresponsible infrastructure cost in roads and utilities. Finally, in gross energy terms the annual energy consumed commuting to town far outweighs the energy saved by the solar system. A 70 percent solar contribution for a well-insulated house in this climate will provide around 21 million Btu (MBtu) per year. Assuming 15 miles per gallon, a round trip to the town located 30 miles away will consume .52 MBtu. This means that 260 commute days per year, excluding shopping, school, and other trips, will consume 135 MBtu or 61/2 times the energy provided by the solar system. And commuting represents only 45 percent of the average family's mileage.

Clearly, a comprehensive energy analysis of development patterns shifts attention from energy technologies to patterns based on social and economic structures.

Transit

Transportation is the largest nonindustrial energy consumer we have, accounting for 25 percent of the national energy consumption. In this realm, as is so often stated for solar design, conservation should precede the implementation of alternative fuel sources. The simplest technique for reducing transportation is to



Capitol Area Plan, Sacramento, Ca. Office of the State Architect. Barry Wasserman, state architect.



Fig. 3. Dimetrodon, Warren, Vt. Architects: William Maclay, James Sanford, Richard Travers.

minimize the distances between home and work, home and commerce, home and school. The reduction of the national average of 13,000 miles traveled per capita would not only be environmentally responsible but perhaps would provide a higher quality of life. The typical family living outside the city limits travels 23 percent more miles or approximately 35 MBtu more per year than the city dweller. This amount of energy would heat an average low-rise condominium in town for one year.

The overall densities, the pattern of daily activities, and the alternate transit systems available are the issues critical to reducing total auto miles traveled for individuals. Distribution of employment sites (decentralizing downtown employment concentrations), decentralization of commercial site location (presence of local neighborhood stores and services), and transit networks (buses, trains, trolleys, bicycles, pedestrian paths) become the significant variables. These concerns in turn can help recreate the kind of human scale urban amenities, such as cafés, neighborhood parks, and local shops, which make higher density communities desirable.

Form, density, and scale

Beyond the implications of density, scale, and pattern on transit are some simple thermodynamic laws relating building form to energy consumption.

The question of optimum building massing, size, and orientation is a complex field and is extremely case specific with respect to climate and building use. How-

ever, it has consistently been shown that row houses and walk-up apartments are more energy efficient than single-family dwellings or high-rise apartment buildings.

The old row house with proper orientation, massing, and its common walls can achieve thermodynamic results similar to those of underground houses which have become a symbol of energy-conserving, extremely well-insulated, environmentally responsive design. The potential energy demand of a multiple-family dwelling can be one-half that of a single-family home. The common walls of a typical row house represent 40 percent of the building's exterior. While burying 40 percent of the single-family dwelling would achieve nearly the same thermodynamic results as common walls, it would be at greater cost.

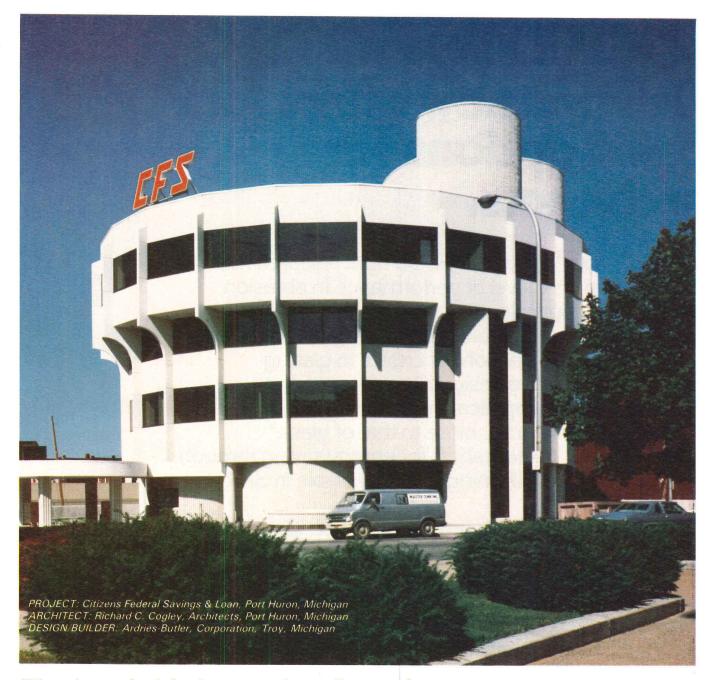
There appears to be a range of optimum building forms and scales dependent on use. In housing, these optimums not only are more cost effective for solar applications but seem to coincide with the requirements of efficient transit for higher density developments. In addition, the low-rise, high-density housing forms are more suitable for district heating and use of the waste heat produced by electrical generation (co-generation).

The use of appropriate glass orientation, thermal mass, shading, and passive solar systems can significantly improve the performance of all forms. However, the single-family dwelling demands more extensive and therefore more expensive modification to provide for its consistently higher energy requirements. There are many examples of excellent passive designs for single-family residences but very few for multiple-family applications. This is not because passive solar is inappropriate for these building types; in fact the reduced loads tend to make this application more cost effective. Lack of development is due to both common preconceptions and government policy about passive solar feasibility.

Higher density housing and mixed-use planning also address the larger social issues surrounding the decay of American cities. Ironically, the solution of those urban problems may be more energy effi-[News report continued on page 50]

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Look for us in SWEETS, Section 7.5/Ce

Creative design with LUCITE sheets: Du Pont now offers four basic options for architects.

Now, with "Lucite" SAR, Du Pont research has established a new level of performance in abrasion resistance for optically clear acrylic sheet. Du Pont's broad line of four different "Lucite" acrylic sheets gives architects greater freedom of choice in glazing materials for creative designing.

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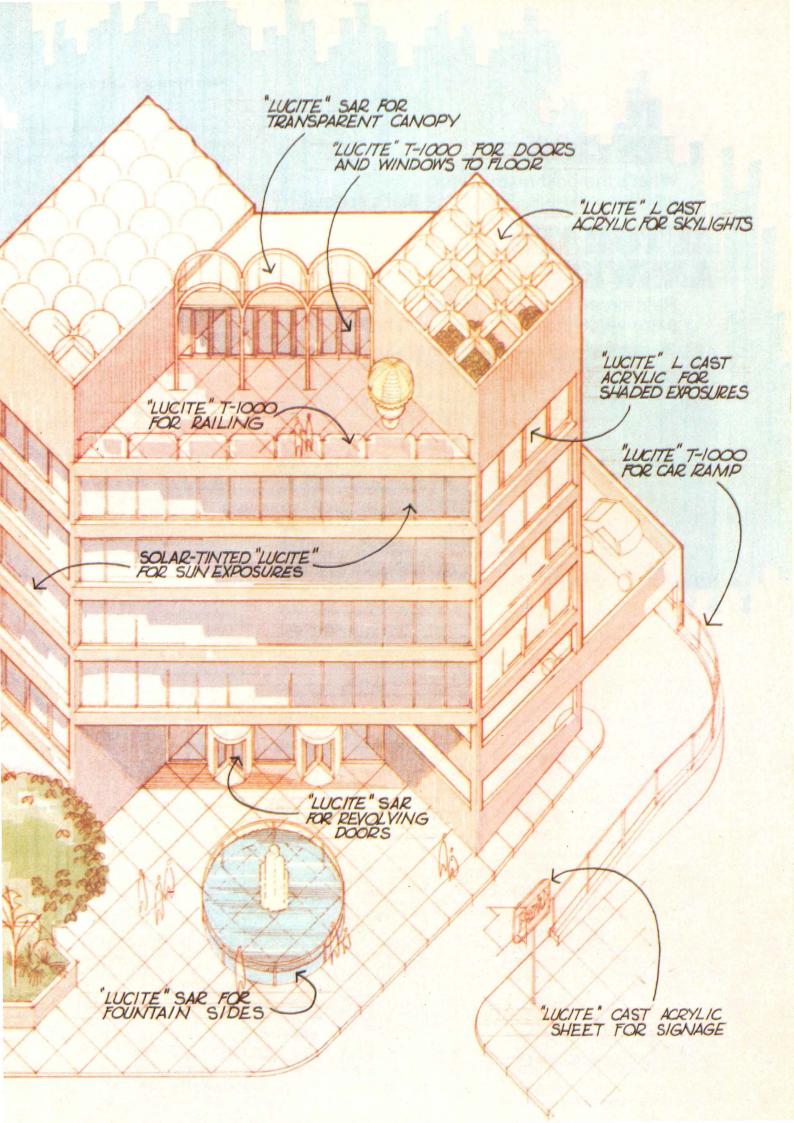
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Claim based on standard measurements according to ASTM D-1044; ANSI Z26.1-1966. Suitability of "Lucite" SAR for any specific application should be verified through appropriate testing by the user.





AUTO **QUESTION:**

What's the best material for a parking garage—even one that's special?

AUTOMATIC ANSWER:

Reinforced concrete delivers extra versatility and special strengths.



When it was time to expand the Sutter-Stockton Garage in San Francisco, design choices were carefully evaluated. The needs of the structural addition were special because of today's more stringent earthquake code requirements.

Instead of simply adding on a separate structure, the designers decided to integrate the new with the old, structurally connecting the two, to make the total structure conform to the new seismic code.

The designers' choice: cast-inplace, reinforced concrete. Its versatility simplified the addition of the new 11-story structure to the existing 7story garage. Concrete also provided the thinnest possible floor system for the relatively long spans needed for traffic flow.

And, more importantly, reinforced concrete was the most economical, adaptable, and dependable solution to an upgraded earthquake-resistive system. The designers adapted a new style of reinforcing for coupling beams that increases their rotational ductility.

Diagonal struts tied into a rectangular column were used in coupling beams to give as much as 60% more inelastic strength and at least twice the toughness in resisting earthquake forces as conventional reinforcing

Reinforced concrete also met stringent building code fireproofing reguirements. And the permanent, textured appearance made the addition a positive contribution to the downtown area.

There's no question about the versatility of reinforced concrete for parking garages of all types. Because it has the answers. Write for Bulletin 7802.

Architect: Sokoloff-Hamilton-Bennett, AIA, San Francisco Structural Engineer: H. J. Degenkolb & Associates, San Francisco General Contractor: Cahill Construction Company, San Francisco Owner: City and County of San Francisco, **Uptown Parking Corporation**

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THE ANSWER'S IN REINFORCED CONCRETE

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News report continued from page 46

cient than solar. Climate-responsive design, including solar systems where applicable, can have its greatest impact in urban centers.

Some recent development plans, focused more on creating humane and vital town centers than energy or resource conservation, present many of these ecological features. The recently adopted Capitol Area Plan for Downtown Sacramento calls for mixed, low-rise residential and commercial development in a zone dominated by office buildings evacuated every day at 5:00. Although the plan calls for energy conserving features in buildings, conservation was not used as a major rationale for the land use. But these mixed-use high-density plans will minimize the transit, infrastructure, distribution, heating, and cooling requirements of these areas.

The primary image of solar suburban development, in contrast, has been a decentralized, do-it-yourself, small-business alternative to massive technologies. In a direct way, the solar home reinforces the notion of living autonomously and therefore diminishes the sense of interdependence necessary for comprehensive solutions to interactive environmental problems.

The alternative to single-family detached solar homes is not necessarily leisure condominiums or high-rise housing projects. Individual expression in a planned highdensity context is demonstrated in residential areas of many older cities where architectural diversity, visual complexity, and personal uses still exist. In Vermont, some individualized high-density housing was developed by commonly building a foundation (with correct solar orientation) and allowing individuals to build as they pleased on any purchased section (see Fig. 3). Row-house zoning allows cohesive development by individuals. Residential cooperatives offer an opportunity for groups of individuals to participate in designing complexes which are normally left to speculative developers.

It is clear that the infrastructure, pattern, density, and transit networks of residential development can have greater impact on resource conservation and energy consumption than any alternative technology. Development must be seen in a social, political, and environmental context in which solar and other alternative technologies are tools for new settlement patterns rather than compensations for the faults of the old.

[Peter Calthorpe, Susan Benson]

Peter Calthorpe is a passive solar designer with the Inverness, Ca, firm of Van der Ryn, Calthorpe and Ptnrs.

[News: Eleni Constantine except as noted]

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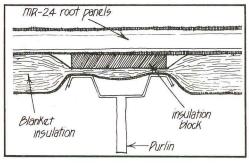
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The MR-24® roof—the only true, double-lock, standing seam metal roof system on the market—is now available for use on virtually any structure: conventional, preengineered or a combination.

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And, because it is today's finest roofing system, the MR-24 roof will change the way you measure the performance of all roofs.

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Unequalled energy efficiency.

No built-up or metal roof can come close to the MR-24 roof in energy efficiency.

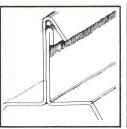
Just 4 inches of insulation, plus special insulation blocks at the purlins, give the MR-24 roof an exceptional tested U value of .08. A fact that can mean lower utility bills, and savings for years to come. (See "Comparative U values" chart.)



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Built-up roofs use organic materials. But the MR-24 roof uses aluminumcoated or galvalume steel, which won't crack, peel or decay.

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The unique design of the MR-24 roof gives it a U.L. Class 90 wind uplift rating. This means it has been proven in tests with winds equal to 200 MPH. And that can mean substantial insurance savings in some areas.

Energy-efficient, durable weathertight, adaptable, easily installed and maintained.

Only one roof system of back all those claims with a record of proven performance: the MR-24

roof. Shouldn't it on the next building you design?

Comparative U values.

•		
Roof System	Calculated U value	Butler te
1. Built-up roof with		
metal deck	45	*
2" insulation	.15	_
4" insulation	.07	*
2. Industry stan- dard metal roof		
2" insulation	.12	.19
4" insulation	.06	.12
3. Butler MR-24		
Roof System		
2" insulation	.12	.12
4" insulation	.06	.08
6" insulation	.04	.07
o madiation	.04	.07
*No tested U values available	1.	

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PPG: a Concern

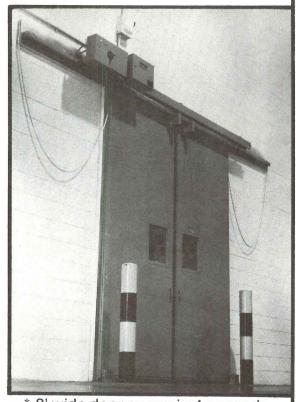




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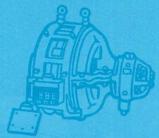
ENERGY MANAGEMENT VIEWS FROM THE NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION VOL. III, NO. 1

THE ENERGY SITUATION — VIEWED FROM 20-20 HINDSIGHT.

It's difficult to tell when the turning point actually occurred. Perhaps it was in 1950, when we began to import oil because it was cheaper than oil produced at home. By 1973, we were helplessly addicted to foreign oil, at any price. Maybe it was in 1978, when we began to quietly import natural gas.

It might have been in 1979, when the country finally began to try and conserve energy. The "Energy Conservation Standards for New Buildings Act," PL-94-385, Title III, emphasized the need to conserve energy, beginning with new building design. Plenty of examples were constructed in the early 1980s, showing what could be done when the architects were given energy efficiency as the design priority. But it wasn't enough. By then, the trend was already irreversible.

Maybe the problem was just too subtle to get the support of a majority of voters. It had accomplished its insidious damage before the symptoms really became obvious. From this perspective it now seems probable that it was consumer apathy that did us in. That should have been obvious by 1980. If only we could have seen where we were headed.



The economics of supplying power for manufacturing shifted to electricity sometime shortly before 1985. Even though the cost of electricity was climbing, it became more profitable to run plants with energy created from coal, uranium, or hydro-power.

Imported oil had gotten scarce at any price, and gas production from new methods such as coal gasification didn't pan out as expected. Neither did oil from shale. Attempts to import the enormous amounts needed were turned back by foreign suppliers who decided that the American dollar was no longer a viable medium of international exchange.

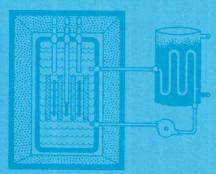
In retrospect, the final turning point may have occurred in 1988.



By then, the voters had a taste of life with \$10,000 automobiles that averaged 27.5 miles per gallon of gas that cost \$2.25 per gallon. Inflation became hopelessly confused with

capital gains. Strangely, it wasn't until then that public demands for more electric generation began. But the damage had been done.

There we were, with hundreds of years of coal in the ground. But we could not mine it fast enough, and we could not burn it clean enough. By then, nuclear power was closed out as an option and it was impossible to restart the construction program that was abandoned in 1985 when delays had lengthened the time to build a new generator to nearly 20 years.



Looking back, the biggest problem was probably one of values. We just couldn't seem to put the necessary effort into new energy sources and expansion of electric power. Too many people just refused to face reality. Too many people just would not believe that this could ever happen to our country. They just could not accept that we had to pay the price one way or another. And the Congress went along with them.

If only they could have believed ... if only they could have believed ... if only...

Of course, all of the above is pure fiction. Maybe it is pure entertainment. But, then again, truth sometimes turns out to be stranger than fiction. Whether this scenario becomes fact, or remains fiction, is crucial to our existence as a nation. As you plan for the future, contemplate these things. And depend on a qualified electrical contractor because "if electricity makes it possible, qualified electrical contractors make it practical."

If you are a designer or manager of energy-efficient buildings, we have a free offer for you. Write on your letterhead that you read this page and we will send you a copy of the Total Energy Management Handbook — the most comprehensive guide to energy conservation in buildings yet published. Write soon, because the time for options is growing shorter, and shorter, and shorter...



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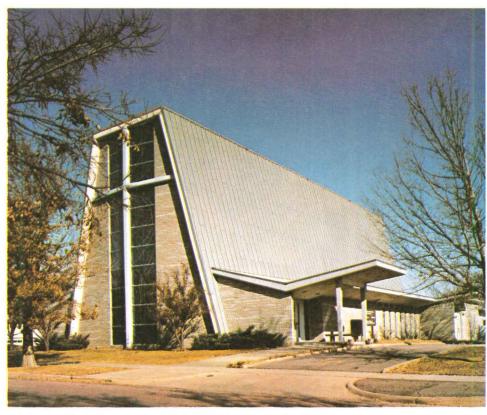
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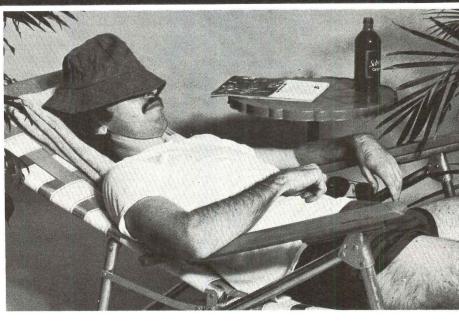


Christ the King Church, Sioux Falls, SD; Architect: The Spitznagel Partners; Installation: Alco Sheet Metal, Sioux Falls



Neurological Clinic, Savannah, GA; Architect: Miller & Bush Architects; Installation:

the pool attendant, it's time to turn the lights off."



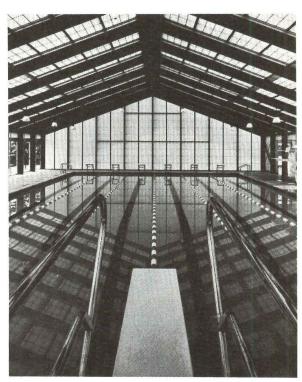
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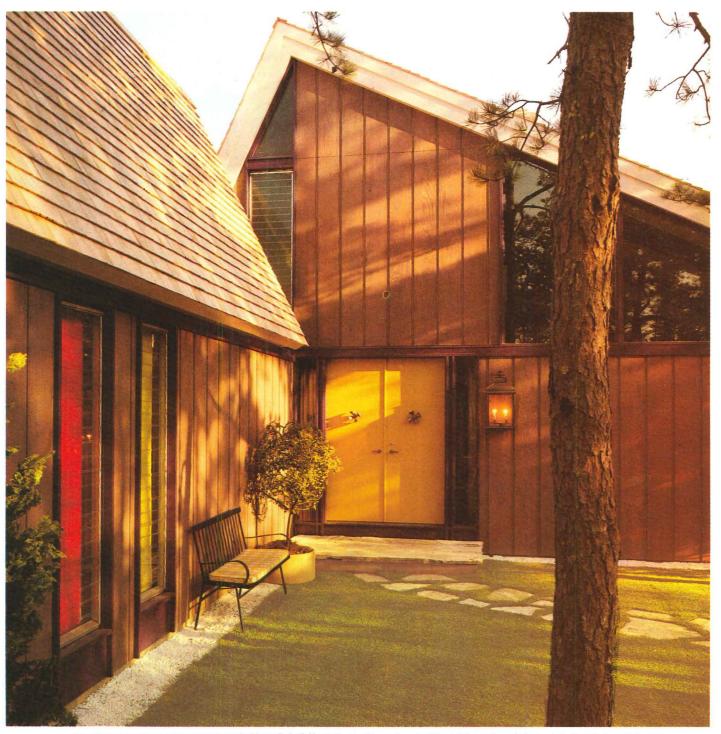
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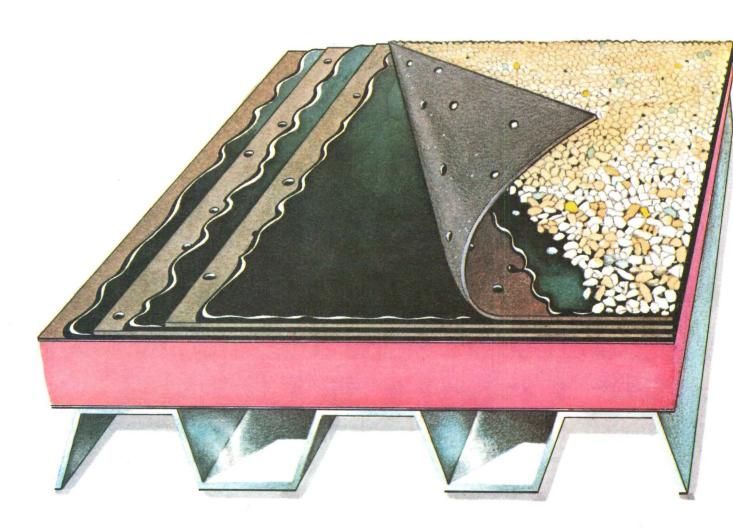
Thermax's isocyanurate foam core is reinforced with glass fibers for greater dimensional stability. It is sandwiched between two asphalt-

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The Green Stuff: Tempchek® Roof Insulation

Tempchek gives you the same high "R" facto as Thermax, with the same top-rated insulating efficiency per thickness. Tempchek also has the same



lightweight, easy cutting, easy handling, easy application characteristics as Thermax, and the same compatibility with hot asphalt.

Its glass-reinforced urethane core gives
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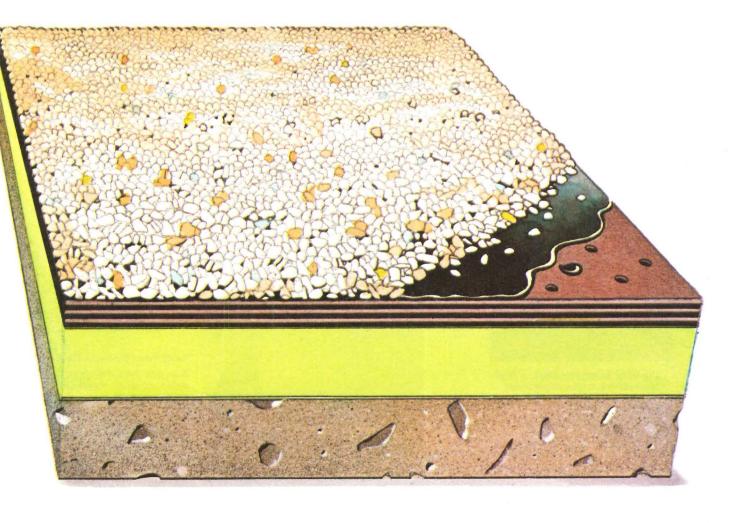
is eliminated. The holes are computer-patterned so they fall in different places in each successive layer of felt. The results are a roof that is easier to install because no brooming is necessary and, more importantly, a roof that is almost blister-proof.

Celotex Vented Ply Sheet further reduces installation cost by requiring only three plies instead of the conventional four. (Over insulation and non-nailable substrates, only three plies are required. And over nailable substrates, lay down three plies and a Celotex base sheet.)

The Pink Stuff, The Green Stuff and The Stuff With Holes In It. They add up to a roof that gives you what you want: maximum insulating efficiency, minimum weight, and no problems. For complete details,

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from top

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Designed and built for complete reliability and long service.
Insulated and gasketed for weathertightness. Exclusive Bilco Thermolatch™ mechanism is activated by fusible link or, when specified, by electrical signal from smoke detector or other emergency device. Sixteen standard sizes and types with UL and FM labels. Special sizes available.

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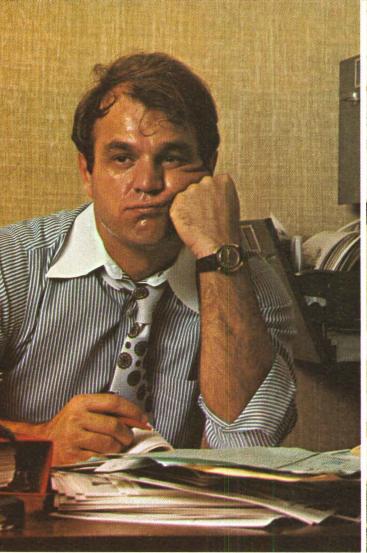
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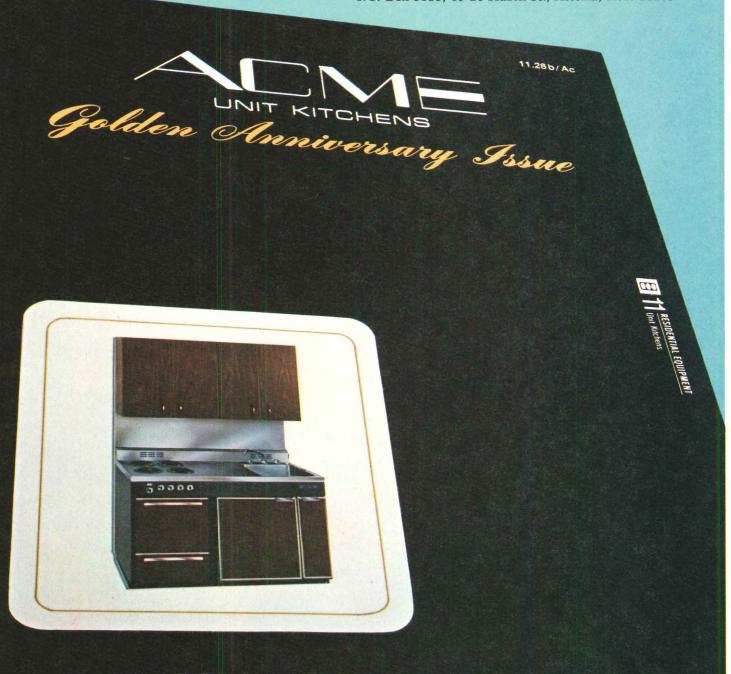
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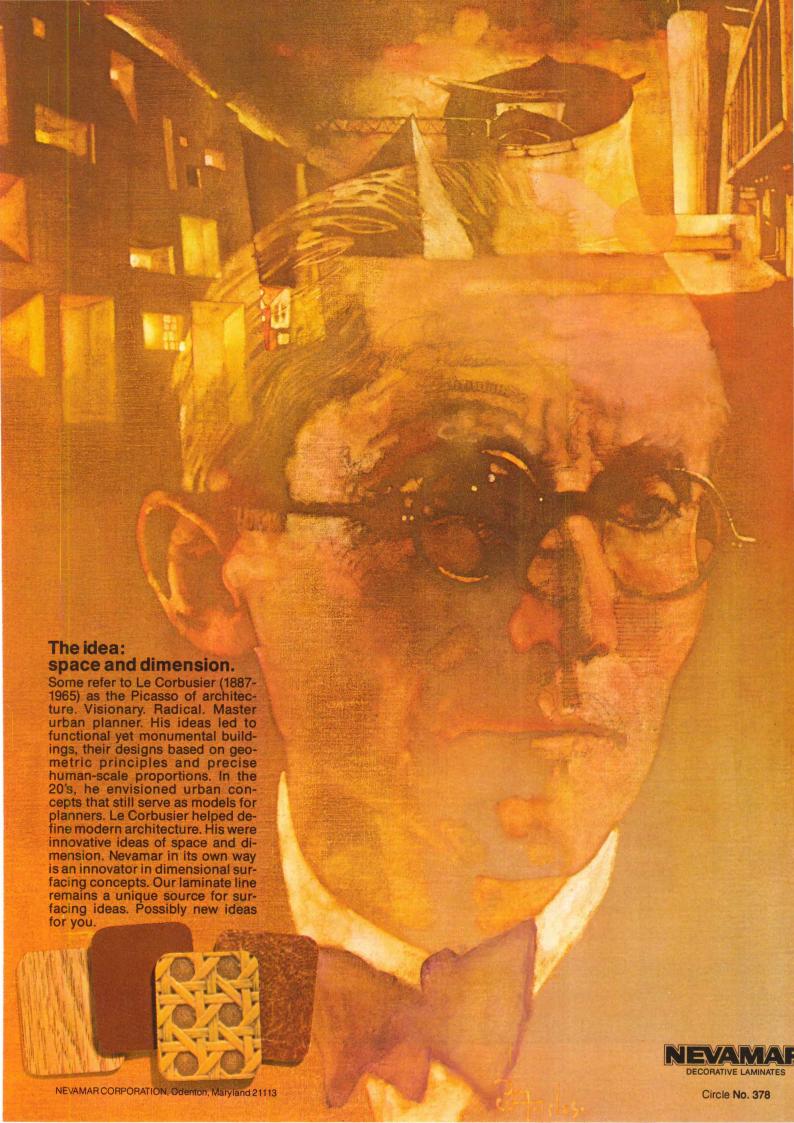
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Introduction: The energy function

Introduction: Part 1 Conservation is beautiful

The intimate role of energy in our lives provides us with a source of pleasure. The art of composing with energy is a new direction for our architecture.

The application of natural thermodynamic energies is an animal instinct. Herds of animals huddle together in the winter for warmth and seek shade in the summer. They only live where they can successfully use the natural energies available to them.

The social and cultural structure that the human animal has created for himself is less direct. In addition to the geothermal, biothermal, tidal, solar, and wind energies available to wildlife, we have fashioned ways of using coal, oil, nuclear and gas as well as hydropower. These sophisticated technologies are designed to augment the shelter we provide in buildings. So many steps removed are we from the rest of the animal kingdom, that we can travel to another planet or be devastated by a fuel shortage. The whole industrial revolution, intent upon creating machines which extend the freedom of man, has served also to enslave him to the fuel needed to run the machines and buildings. Focusing on our fuel bondage has brought attention to energy conservation and energy waste, our grossest national product.

Why do people who know better ignore the intelligent use of energy? It is the same instinct which allows nurses to smoke cigarettes and eat junk food, and energy legislators to drive gas-guzzling cars. For centuries, the same fuels which were associated with work have also been associated with pleasure. It is the transformation of energy states which enables us to do work with machines. Perhaps the luxury of using energy for play makes us feel less like machines.

The reason people are not appropriately concerned may be that they secretly feel that whatever energy shortage there is



A street scene in Niamey, Niger, reflects energy and the natural instincts for good design.

today could be dissipated tomorrow if the need were grave enough. We could let the grass grow, let the snow pile up, park the car and take the bus, park the motor boat and row, produce clothes for replacement only when worn out, and turn the culture into a longevity-conscious culture instead of a throwaway culture.

We also know that, for now, lightning does not strike buildings which ignore the appropriate use of energy. In fact, if the demand for energy goes up with the supply, there is no problem. The culture says: if you can pay for it, you can have it. The only restriction that society has traditionally levied is that the pursuit of one person's pleasure not deny the next person his health, safety, or welfare. Concern has grown in recent years over this system because of cost. The availability has always been related to price, but the price of energy has always been relatively low. The use of energy for pleasure seemed available to everyone, now and in the future.

Energy conscious counterculture: There is in America today a counterculture which is based upon more rational energy consumption. The logic of the counterculture is simple. If the energy resources on this earth either are reduced by present political situations, remain constant, or are nonrenewable in the future, the supply and demand curves must cross at a higher cost each year. To arrive at a lower cost requires that we either increase the supply or decrease the demand. To reduce the demand we must: 1) change the population growth, 2) change the pattern of energy usage by the existing population, 3) alter the machines and buildings which consume the energy, or 4) increase the efficiency of the fuel. To increase the supply we must: 1) use more of the available renewable energy sources (sun, wind, etc.,), 2) grow our own (biomass), or 3) be more efficient in the treatment or reuse of our waste resources (i.e., process garbage, recycle, etc.).

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Introduction

Food for thought: An interesting parallel to draw is between energy consumption and food consumption. The food we eat after all is, in its base form, fuel for our bodies. Other animals move from place to place seeking food. Early nomadic peoples did so as well. As the natural supply diminished and other, more permanent societal influences governed, people sought ways of growing their own food. They planted vegetables and herded animals. In short, when the available fuel supply diminished, they sought ways of replenishing it. Soon home-grown food was passed from one climate to another (as we do now with oil). Of course technology provided ways of preserving food and preparing it that made one food edible which had previously been inedible (as we are now trying to do with solar). As the efficiency of growing our own fuel for our bodies has increased, we have tapped the earth for other fuels to run the farms.

If today's energy problems actually succeed in causing mankind to reevaluate his fuel supply to the point where it becomes necessary to rely upon the replenishable supplies of energy available to us, then we are smack in the middle of a turning point in the history of the modern world as graphic as when the first men decided to herd their own animals and grow their own plants. The difficulty of this task compares to trying to convert back to horse power. How does this relate to architecture? It affects architecture because architecture affects it. About a third of the energy consumed in this country is consumed in buildings. As extensions of the body's ability to withstand the elements, buildings also require fuel. If we think of food as fuel, we also recall that animals are fed. machines consume, but humans can dine. The consumption of fuel for human use should be more than just the intake of fuel; it can be an art.

How can energy use be an art that minimizes waste? The pleasing aesthetics of energy suggest that our buildings not pollute the atmosphere, that they consume fuel efficiently, that the fuel be abundant and replenishable, that the costs be low, that the buildings be safe and comfortable, and, most important to the art of architecture, that the building be shaped, organized, and situated to be as selfsufficient as possible. As with other art forms, these standards of excellence can conflict with one another, but appreciating the thermodynamic beauty of a building is more than a low fuel bill. It is an appreciation of how the disparate mechanical and nonmechanical aspects of the building interrelate to form a whole composition for thermal comfort. [Richard Rush]

The structure of the magazine

This magazine is divided into two main sections. The first part stresses the background and principles of the energy function. The purpose is to represent the issues relevant to the understanding of energy use and conservation in buildings. The second part is designed to present nonresidential buildings which were consciously composed with energy principles.

To accomplish the task inherent in the first part of the issue, we have sought the help of experts in the fields of law and economics, passive and active general building conservation, and passive and active solar design. Each generic overview portion is followed by a more specific article which isolates a particular element of the general concept in some detail. The guest authors' biographic sketches follow:

John P. Eberhard is director of Architectural Research Associates, Washington, DC, and holds degrees in both Architecture and Industrial Management. His career has included positions as director of the Institute for Applied Technology, National Bureau of Standards; dean of the School of Architectural & Environmental Design, State University of New York at Buffalo; and president of the AIA Research Corporation. Recently, Mr. Eberhard began his own architectural research firm and publishing company. The emphasis of these organizations is on research to improve the processes of designing and constructing buildings.

Senator Charles H. Percy was chairman and C.E.O. of Bell and Howell Company when he became the Republican candidate for governor of the State of Illinois in 1964. In 1966, he successfully campaigned for this first term in the U.S. Senate. The Senator was reelected in 1972, carrying all of the state's 102 counties. In 1978, he was again returned to office. In addition to membership on a series of Senatorial committees, Senator Percy is a leading member of the Solar Coalition in Congress, and is chairman of the Alliance to Save Energy, a private, nonprofit organization.

C.W. Griffin is formerly a senior editor of Engineering News Record. A professional engineer who now serves as a construction consultant and technical writer, he is perhaps best known to architects for his Manual of Builtup Roof Systems, published by McGraw-Hill in 1970. He has authored a series of energy-related books since 1973. His first, entitled The Economy of Energy Conservation in Educational Facilities, was

published by Educational Facilities La ratories. It has been followed by the been followed by the been followed by the been followed by the been followed by Conservation in Buildings: Techniques for Economical Design which we published by CSI. It is reviewed on p.

William Morgan has been fascinated the use of earth in architectural form shis student years. He is presently preping a book on Earth Architecture with Ludwig Glaeser of the Museum of Morgan is a book on Aboriginal Ameri Architecture. William Morgan is best known to architects for his outstanding work as an architect in private practice Jacksonville, Fl. He was chairman of the AIA Committee on Design in 1978.

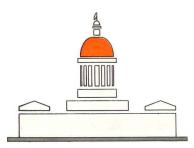
J. Douglas Balcomb is assistant divisi leader for solar research at the Los Al Scientific Laboratory of the University California in Los Alamos, NM. In recei years, Balcomb has become a respec leader and spokesman for the effective use of passive solar heating and cool the US. He is presently chairman of th International Solar Energy Society, Ar ican Section, and was founder and im diate past chairman of the Passive Sy tems Division of ISES. The research underway at the Los Alamos Scientific Laboratories includes a DOE grant to itor buildings throughout the U.S. which use the principles of passive solar de-

Sandra Oddo is a solar energy writer based in Hancock, NH (7000 degree days). She is a founding editor of Sola Age Magazine and a former staff write House and Garden. Before 1970 she a critic for Newsweek, Life, and The L Angeles Times, and she served as a cultant for the National Endowment for Arts—until thoughts about the future renergy more relevant. Her book, Life of the Nearby Star: Some Implications of Solar Energy Use, to be issued in 198

Christopher Johnson is currently a member of the Minneapolis firm Architural Alliance. His prior experience included major responsibility for the Minimum Energy Dwelling, and for the velopment of the M.E.D. Workbook. With the firm of Burt, Hill, Kosar, Rittelr & Associates of Butler, Pa, Johnson with project architect for the Pennsylvania University Solar Laboratory. His constand advisory experience includes the Minnesota Energy Alternatives Lobby HUD reviewer of solar system grants, the National AIA Energy Information Cimittee.

The laws of nature and the nature of law

John P. Eberhard and Senator Charles H. Percy



A review of the development of energy standards legislation in building design and the positions emerging in response to the proposed performance standards.

Over a long period of time we have begun to understand the laws of nature. These have been determined by forces outside of our control. We cannot change them. On the other hand, the laws made by man are determined by government. It is in their nature to be constantly revised.

The formal processes of architectural design toboggan down a course shaped by the supportive and constraining aspects of both sets of laws. The irremediable laws of nature provide for structural stability through the action of gravity while at the same time gravity poses the constraints of possible collapse if we fail to design properly. The laws of man support the contractual basis for doing business while also including penalties for failure to design properly.

While we were in school most of us studied the laws of nature that relate to energy conversion, utilization, storage, and depletion. But it is only within the last few years that we have become aware of the growing body of man-made laws surrounding the exploration, supply, and use of fossil fuels. Congress has enacted laws which provide incentives for energy conservation as well as regulations (most recently, the National Energy Act and National Energy Tax Act). This article will focus on one example of regulations: The Building Energy Performance Standards (BEPS) being developed by the Department of Energy (DOE).

Laws of nature

What is clearly intended by most "energy legislation" is to avoid the waste of fuel, specifically oil and gas. Energy use in buildings is the result of "work" being done

to provide the comfort and support services which users need or desire. These needs and the energy required to meet them form the "energy budget" of a building. How alternative sources of supply will be harnessed to meet this budget is part of the design decision.

There are ways other than consuming oil and gas to use the energy conversion potential of nature to provide for human comfort. These include ancient principles of harnessing the wind, the movement of water, natural daylight, and the warmth of the sun. Congress should continue to encourage the use of alternatives such as these and other renewable resources to reduce our dependence on scarce fossil fuels. As illustrated in other articles in this issue, the utilization of passive and active solar energy, for which Congress has provided incentives, can be a major design opportunity. Too often, however, legislation aimed at reducing the wasteful use of oil and gas as supply sources does not adequately distinguish between general use of energy in buildings and specifically controlling waste through better design.

The nature of law

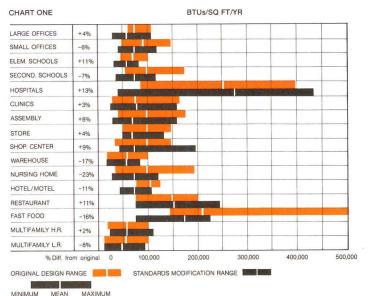
Under our Constitution, the Federal Administration has no police power with respect to the protection of health, safety, and welfare unless specifically designated by Congress. This police power resides primarily in the state governments. The Federal government can use rewards and sanctions to get state governments to adopt regulations, but the Congress must first find constitutionally acceptable reasons for allowing the use of sanctions. The development of building energy regulations must be understood in the light of this Constitutional constraint in order to understand why adoption and implementation by states is a key provision.

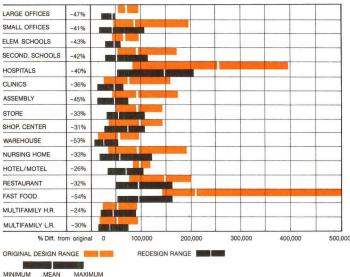
In implementing any energy regulations, Congress should address these crucial questions: 1) Is there a clear need for regulation? 2) How can the regulations be written in a way which achieves substantial reductions in the demand for oil and gas? 3) How can the regulations be framed in the "least intrusive" way to achieve the intended purpose?

When the regulations legislated in the past few years by Congress to control the use of fossil fuels in buildings and to stimulate the use of alternative sources of energy are tested against these questions, it appears that Congress has been well intentioned but some of its actions have been of dubious value.

History of Energy "Standards" Law

The "forced" adoption of ASHRAE 90-75 by most states under the EPCA regulations is a case in point. Under the pressure of EPCA (PL 94-163: The Energy Policy and Conservation Act of 1975), states began in 1976 to formulate legislation designed to regulate building design with regard to energy use. In establishing building energy requirements for participating states, the Federal government relied upon ASHRAE 90-75—standards established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers. The American Institute of Architects (AIA) and others complained of the prescriptive nature of ASHRAE 90-75. Although supporters of ASHRAE 90-75 argue that the individual chapters of this document may be seen as component performance standards, taken as a total set of standards it prescribes a conventional building assembled from conventional parts. As Chart One shows, architects and engineers in normal practice are already designing buildings which meet or exceed the ASHRAE 90-75 standards. These further assume that it is the building and its components which use energy, essentially ignoring the human activity which generates the energy needs. Even that





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ENERGY PERFORMANCE RANGES IMPACT OF STANDARDS MODIFICATION

ENERGY PERFORMANCE RANGES IMPACT OF REDESIGN

CHART TWO

portion which pays token attention to energy supply alternatives (Chapter 11) can be used only by first designing a conventional building which establishes the energy budget. Passive design solutions which place no demands on mechanical solutions are not easily given credit by this process. However, no other substantive reference was available to the states in 1976.

With a grant from the Energy Research and Development Administration (ERDA), the National Conference of States on Building Codes and Standards (NCBCS) developed a form of ASHRAE 90-75 which could be used as a portion of a building code. Additional funds were given to the Council of American Building Officials (CABO) to develop educational programs for building code officials, to help them understand how to review building plans and specifications for compliance. ASHRAE 90-75 was clearly on the way to being institutionalized.

In 1976, the AIA realized that its lobbying for a nonregulatory approach based on tax incentives was not getting a favorable response from Congress. As a result, the AIA's Energy Policy Committee approached the leadership of ASHRAE and gained their cooperation in a joint effort to explore the improvement of ASHRAE 90-75 and to work towards the development of "performance" standards. While some architects objected to cooperation with ASHRAE as implying a degree of endorsement of ASHRAE standards in their present or corrected form, AIA believed it better to cooperate on the development of "performance" standards than to be in flat opposition to ASHRAE. But the result has been to make it difficult for the AIA to oppose the EPCA legislation at the national level. However, in some states where local architects were more politically adroit, they were able to get the state legislature to provide for the eventual adoption of performance standards even though the state would propose to adopt some form of ASHRAE 90-75 as an interim measure. By now 42 states have adopted some form of legislation for energy-conserving design; all but two of these states (California and Ohio) are using ASHRAE 90-75.

In the spring of 1977, the Department of Housing and Urban Development (HUD) began to carry out the provisions of PL 94-385 (The Energy Conservation and Production Act of 1976). This law called for the development of "performance" standards to be issued in August 1979, and to become law six months later. HUD decided that an energy budget approach was the most achievable method for "performance" standards. HUD's early moves were discouraged by their counterparts in the Department of Energy (DOE) who believed that the most viable strategy was to further institutionalize ASHRAE 90-75 because it was in the process of being adopted by various states. There was also internal disagreement: HUD had decided to go to the building industry professionals for the development of the data base and DOE wanted to keep the research internal to the Federal government.

At the time the decision was made to go out to the industry professionals, a prime contract for the development of the "baseline" information for the national energy budgets was awarded to the AIA Research Corporation (an affiliated but separate corporation from the AIA). The AIA/RC in turn awarded subcontracts to the National Association of Home Builders Research Foundation, Syska & Hennessey (engineers), the Ehrenkrantz Group, Heery & Heery, Brown Associates and several others to collaborate in the effort. An Energy Standards Technical Advisory Group was assembled from members of various industry organizations.

This research project was conducted in two phases. Phase I, completed in January

1978, surveyed a representative sample of commercial and residential buildings to determine their designed energy performance. This sample included a wide range of residential and commercial building types and climates in the U.S., and was designed to allow accurate generalizations about the building population it represented. Phase II was a larger research effort designed to produce specific sets of comparative information. The project budget of over \$8 million provided for the participation of more than 700 professionals, the redesign of some 200 representative buildings, and a detailed computer simulation of the energy performance of designs for 600 building variations. The results of this work are summarized in Chart Two.

The dramatic savings of more than 40 percent in these redesigned buildings was the result of "energy conscious design." The principle, simply stated, is: "Buildings do not require energy; it is the requirement of people for comfortable conditions under a variety of climatic conditions which generates the need for satisfactorily designed environments." This principle seems obvious, but the dominant mode of energy "conservation" thought is produced by an engineering mentality that sees the energy-using equipment as the target of research, regulations, and building design. When a building complex (such as a university campus), or a single building (a church), or a room (extra bedrooms in a house), contains no human activity, there is no reason to provide comfortable conditions. Stuffing the walls of a building with insulation (insulation, though a good idea. has tended to be oversold) or putting sophisticated controls on an overdesigned air-conditioning system, bypasses the crucial issue of rethinking design to reduce energy-consuming HVAC systems.

The issue before Congress and the Administration is at what level to set the

energy performance standards. DOE published preliminary proposed levels in the Federal Register in December 1978. It is their intention to update those preliminary levels in another Federal Register publication scheduled for late February. Concerned parties have several months to comment on these published standards. In August of 1979, the final standards are to be forwarded to Congress with the Administration's recommendations for implementation. One issue to be addressed at that time is whether the standards should be mandatory or optional.

What lies ahead

Energy-conscious design has not been very high on the agenda of the architectural profession. Commonly, it has been seen as an engineering concern and a design constraint. The history of recent legislation, especially at the state and local levels, reflects this view. So do current positions on the general issue of energy standards, which include:

- 1) A position opposed to any further regulation of the building industry. This is a position popular with architects and builders, especially if they do not believe (or do not wish to recognize) that there is any substantial "energy crisis." Many people believe that there will be either new discoveries of oil and gas to increase the supply of fossil fuels, or a technological remedy (nuclear energy, coal gasification, etc.). It does not appear to be realistic, however, to adopt a policy based on either expectation and as a result to go on wasting oil and gas in buildings. It is possible and desirable to design more energy-conscious buildings. The issue is by what means can Congress and state legislatures ensure energy-solving design?
- 2) Another position is to argue that the marketplace could produce sufficient economic incentives to bring about energy-conscious design. If the cost of fossil fuels continues to increase at the rate of 15 to 20 percent per year, building owners and users are going to become more and more concerned about how their buildings use energy. Government could encourage the construction of energy-conscious buildings by:
- a) Setting a good example in their own building programs.
- b) Supporting and encouraging educational and informational programs that let building clients and building professionals know what is possible. The *Alliance to Save Energy* (an organization chaired by Senator Percy) could organize an information program for building clients, as one example
- c) By providing tax incentives to the private sector and tax-supported grants to nonprofit institutions. Recent legislation resulting from the National Energy Conserva-

Basic differences between the federal BEPS and ASHRAE 90-75R formats

ASHRAE 90-75R

Presents design requirements for some, but not all, subsystems.

Within the subsystems covered, there are a number of variables. Energy-consumption levels for buildings of a single facility type and in a single region will vary.

Building classification is considered only in a general way.

Makes no assumptions about facility operation.

A static standard, considering energy consumption at a single point in time.

Requirements are presented by component and subsystem; designer may make trade-offs (under Chapter 10) only after doing an initial design that meets the subsystem requirements.

Passive systems may be considered only after doing an initial design that meets the subsystems requirements.

Requirements are largely independent of siting and site features.

Energy analysis is not required (Chapter 10 allows an optional energy analysis).

Preliminary BEPS

Presents a single design energyconsumption goal for entire building.

Major variables determing energyconsumption levels are facility type, climatic region, and fuel selection. A single goal is stated for all buildings of the same type in a region.

Facility use is a major factor.

Assumes a standard facility operating pattern over time.

A dynamic standard calling for the calculation of energy consumption over a year and taking seasonal fluctuations into account.

Energy consumption of all subsystems is considered; allows designer to make trade-offs.

Encourages use of passive systems within the building.

May consider site conditions, orientation, microclimatic factors.

Requires a complex calculation of annual energy use (usually by computer).

tion Policy Act does some of this.

3) A third position, more consumeroriented, holds that the nature of the marketplace will prevent it from being as
responsive as the situation requires.
Speculators who construct buildings for
immediate resale will always attempt to
minimize the initial cost of the building, and
will not make any energy-saving investment which would add even minimally to
that first cost. Speculative housing will
probably pay only token attention to
energy-conscious design until the homebuying public becomes more concerned
about energy costs.

Moreover, dollar costs alone are not a sufficient measure of the value of not depleting the earth's finite supply of oil and gas. Just as government has set aside land for future generations by creating parks, far-sighted policies should conserve energy resources.

This third position can make a good case for regulations in the national interest to control the design of buildings with regard to their energy consumption. PL 94-385 reflected this position to a certain extent in requiring that there be "standards" for energy and buildings.

How the Department of Energy decides to carry out this law is not yet clear, but it is critically important. If the energy budgets for national purposes are set to be compatible with ASHRAE 90-75 (a politically comfortable policy), the building industry will get another major regulatory hurdle, and

the country will save no fossil fuels, because professionals are already designing at that level in response to market conditions (see Chart One). The few buildings not likely to be responsive to these conditions are not sufficient reason to regulate all buildings.

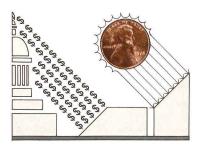
If these new standards are to accomplish their intended purpose, they will have to provide a genuine challenge to architects, engineers, and the building industry. There is sufficient economic incentive to set rigorous standards, and there is a clear indication that it is technically possible for designers to meet the challenge by using the principles of energy-conscious design. If the new regulations to be produced under Public Law 94-385 are tied to energy budgets which are a challenge to the profession, a new burst of creativity could emerge. \square

Note: The comparison of BEPS and ASHRAE 90-75R reproduced above is taken from the "Building-Community Workbook" prepared by the National Institute of Buildings Sciences with the permission of NIBS. The comprehensive workbook is available from NIBS, Pennsylvania Ave., Washington, DC, for \$300.

The workbook was drawn up by NIBS in order to assist the building industry and community in responding to the ANPR.

Penny-wise, dollar-foolish

C.W. Griffin



A veteran energy author discusses the economic deterrents to energy-conserving design measures inherent in the present tax laws, and proposes a standard energy tax reduction as a potential solution.

To bureaucrats, the shortest distance between two points is a spiral, and the Department of Energy's proposed building energy performance standards (BEPS) offer still another illustration of this bureaucratic axiom. Instead of appealing directly to building owners' economic self-interest to cut energy consumption, the DOE performance standards travel the circuitous path of regulation. Complete with RIFs, (Resource Impact Factors) and RUFo (Resource Utilitization Factors), the acronymous governmental jargon that can convert the simplest ideas into metaphysical muddles, these DOE standards seem designed more to make work than to conserve energy.

The real fault, however, lies not with DOE, but with Congress's obstinate refusal to confront the energy problem. In the 51/2 years since the Arab oil cutoff officially signaled the end of the cheap-energy era, federal energy policy has generally moved in the opposite direction from conservation. Federal tax and financing programs have actually increased the wastepromoting subsidies in effect during the 1973 oil embargo. The post-embargo imposition of gasoline price controls, Congress's benighted resistance to naturalgas price decontrol, and the increased federal share of our monumental highway-building subsidies prevent the natural operation of market forces from resulting in energy savings.

Compared with the profligate waste represented by the subsidized cult of over-powered automobiles, buildings make a relatively modest contribution to the collec-

tive national energy-wasting effort. But as one of three major classes of energy consumers (along with transportation and industry), buildings rank second (to industry) in accounting for about 30 percent of the nation's total energy consumption. Probably a third of this energy consumption could be eliminated by current technology. How can we realize these vast potential economies?

The need for tax reforms

DOE's regulatory approach errs in totally ignoring users' economic interests and making the implementation of energy-conserving measures needlessly complex.

Consider, for example, the required RUF calculation (designed to account for the additional energy required to convert and transport building energy). It is unnecessary, because energy prices already include the costs of distribution and transportation. Electricity, which carries an RUF nearly three times that of oil and gas, generally carries a unit price at least that high in proportion. A rational, market-determined price system could promote energy conservation, if the market weren't distorted by benighted governmental policies.

To see how the game's rules—i.e., the tax laws—discourage conservation, consider a Business Week report of a major cement producer's rejection of an energy-saving investment that appeared to be an unrefusable offer. The cement producer rejected a \$2.7-million wasteheat reclamation system recommended by company engineers, despite its promise of \$775,000 annual fuel cost savings, three and one-half-year payback (22 percent annual pretax return). The company's finance committee overruled the engineers, demanding a two-year payback (42 percent annual return) to justify the energy-saving investment. (Business Week, 4/25/77, p. 77.)

This energy-wasting decision stems, of course, from the federal tax laws, which generally cut the operating savings in half (to 52 percent, to be precise). Because operating expenses are totally deductible in the year incurred, whereas capital investment must be depreciated over equipment service life, the energy waster shares the cost of his annual waste with U.S. taxpayers, and a 22 percent pretax saving becomes a much less attractive 11.4 percent. Conversely, the energy conserver pockets only half the savings accompanying an energy-conserving investment.

This tax feature means that solar energy competes under a tremendous handicap. The high capital cost of solar energy is deductible only in periodic annual depreciation, a feeble economic incentive compared with the immediate tax deductibility of annual fuel-operating costs. The socially beneficent owner who invests in solar energy and spares the nation the inflationary effects of importing oil is rewarded with a higher tax bill than his energy-wasting counterpart.

Conservation by fair representation

The solution to the problem is astonishingly simple—in principle, if not practicality. Take the DOE performance requirements in Btu/gsf for various building types and make them the basis for standard allowable energy tax deductions. Such a standard tax deduction, computed simply by multiplying a building's gross square footage by deductible energy use (Btu/gsf/yr) and by regional cost factor, would reflect 100 percent of the building owner's actual energy saving, instead of a mere 52 percent.

Tax reform for energy conservation

Many features of the tax laws promote cheap, energy-wasting design. Assume that the building owner considering the illustrated investment (in efficient HVAC) is

a corporation taxed at 48 percent. Although HVAC System B offers a 16.8 percent pretax return, it offers only a 10 percent effective after-tax return, because it reduces the corporation's tax-deductible expenses by \$25,000 in the first year (\$30,000 in operating and maintenance expenses—\$5000 in straight-line capital depreciation, 5 percent of the \$100,000 additional capital cost for HVAC system).

With a standard energy reduction, however, the pretax return becomes the after-tax return. It is, moreover, effectively increased by additional capital depreciation deduction. If the return on a \$100,000 additional capital investment is 16.8 percent, then capital depreciation effectively increases this return in the first year by 48 percent of 5 percent equaling an additional 2.4 percent, raising the first year's after-tax return to 19.2 percent.

Thus for investment decisions by corporation building owners taxed at 48 percent rate, we could provide an additional 8 percent after-tax return for energy-conserving investments merely by abolishing the current tax subsidization of energy waste and replacing it with a standard energy allowance based on building type, climate, local energy cost, and gross sq ft.

Such a reform would be less complex to administer than many regulations in our current loophole-ridden tax code. It need not be economically disruptive, since energy budgets (for computing allowable tax deductions) could be set at, say, 120,000 Btu/gsf annual rate for office buildings in most climates, with similarly liberal allowances for other building types.

There are other desirable tax reformsnotably repeal of accelerated depreciation formulas—which encourage quick sales of cheaply built, energy-leaking buildings. But the standard energy tax reduction is paramount. It would stimulate more energy conservation, faster with far less governmental effort and expense than the DOE's regulatory approach. Overnight, it would double the return on energyconserving investments, a tremendous incentive for continuing energy-conserving efforts beyond anything contemplated by the DOE standards. And it could operate in conjunction with minimal code requirements designed to ban inexcusably wasteful design.

The "bottom line" is the ultimate arbiter governing business decisions in the U.S. economy's private sector. It could be an equally powerful stimulus in promoting such socially beneficent goals as energy conservation. If a standard energy tax deduction were enacted, the U.S. could see the greatest energy-conservation effort in history, as private owners, who formerly wasted energy at public expense, suddenly began to conserve it for private gain.

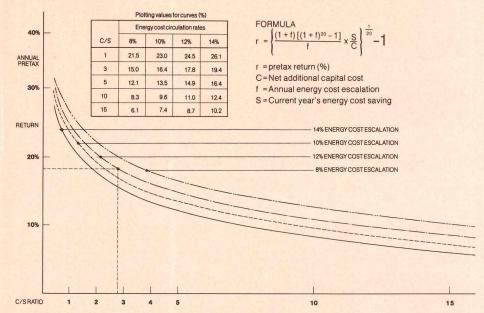


FIG. 1

The following simplified example shows how a change to a standard energy deduction would result in attractive financial returns for some currently borderline energy-conserving investments. First, compare two HVAC systems, both with assumed 20-year service lives, and the following cost factors:

HVAC System A	HVAC System B
Total first cost = \$1,000,000	\$1,100,000
Annual maint. cost 25,000	20,000
Annual energy cost,	
(current, Year 0) 105,000	80,000
Annual O & M \$ 130,000	\$ 100,000

Assume energy cost escalation = f = 12% maint. cost escalation, m = 8% Tradeoff is \$30,000 current year O & M saving (plus higher savings in succeeding years) vs. \$100,000 higher capital investment for HVAC System B.

20-yr future worth of Annual 0&M saving = Energy saving + maint. saving Energy saving = \$25,000 $\frac{(1+f)[(1+f)^{20}-1]}{f}$ = \$25,000 $\frac{(1.12)[(1.12)^{20}-1]}{0.12}$ = \$2,018,000

Maint. saving =
$$\$5,000 \frac{(1.08) [(1.08)^{20} - 1]}{.08}$$

= $\$219,000$
20-yr future worth = $\$2,018,000 + \$219,000$
= $\$2,237,000$

Pretax return on investment =
$$\left[\frac{2,237,000}{100,000}\right]^{\frac{1}{20}} - 1$$
 = 16.8%

Simplified approach:

Assume total 0 & M escalation = 12%, $C/S = \frac{\$100,000}{30,000} = 3.3$

From Fig. 1 graph, Pretax return = 17% Years to Payback

$$n = \frac{\left[\log \frac{C}{aS} (a-1) + 1\right]}{\log a}$$

in which
$$a = \frac{1+f}{1+i}$$
, $f = \text{annual } 0 \text{ MM } \text{ cost escalation} = 0.12$

$$a = 1.018$$

$$i = \text{ interest, or discount rate} = 0.10$$

$$n = \frac{\log \left[\frac{3.33}{1.018} (0.018) + 1 \right]}{\log 1.018} = \frac{.02487}{.0078}$$

$$n = 3.2 \text{ yrs}$$

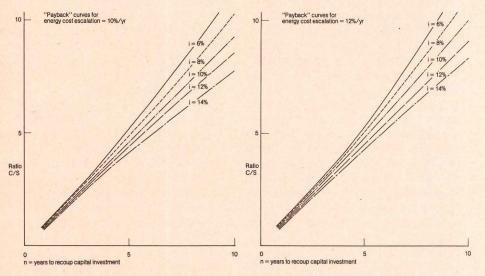
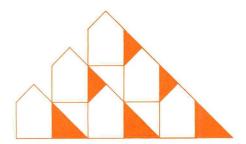


FIG. 2A

FIG. 2B

Right to light



The best things in life may be free, but that does not guarantee your access to them. Through Ralph Knowles's solar envelope, though, all could have the sun.

In a 1959 court case in Miami Beach, Fl, the Eden Roc Hotel sought an injunction against its neighboring Fontainebleau Hotel to prevent it from building a 14-story addition that would block sunlight from the Eden Roc's pool. As described in Connecticut Law Review (Vol. 10:123), the Eden Roc alleged that the Fontainebleau was acting maliciously in the construction of the new addition. The court agreed, and enjoined construction on the grounds that one may not use property in a way that causes injury to another. However, an appelate court reversed the decision on the grounds that the doctrine cited to support the decision did not apply, since that doctrine could only be used to protect the lawful rights of others. The court held that no lawful rights of the Eden Roc had been taken, despite the fact that evidence suggested that the new addition was to be built "partly for spite."

In the U.S., this case has become the leading 20th-Century case on implied easements of light and air. It upheld, as have others, the notion that one is not guaranteed the right to light that enters through another's property. The implications of such a decision could have serious consequences for anyone using or contemplating the use of solar energy devices. While one is guaranteed the right to access to light that enters one's property vertically, that light does not always meet the needs for solar collectors or even for simple solar insolation. As of now, only one state law guarantees access to light entering through another's property, and that is New Mexico, which in 1977 enacted a "first in time, first in right" sunlight statute. But many question whether, if challenged,

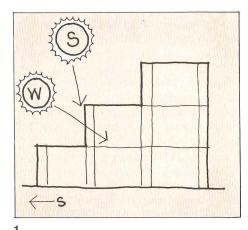
it could be shown to be constitutional.

The most logical areas where adequate solar access could be guaranteed would be in new building developments, and some in fact have already been established with such agreements between property owners in the form of easements and restrictive covenants. In such cases, solar access is protected at the local level, as is any other zoning restriction. For instance, the State of California's new Solar Rights Act, as described in the Los Angeles Times (Dec. 10, 1978), authorizes local governments "to require by ordinance the dedication of easements to assure that each lot in a (new) subdivision receives sunlight across adjacent lots as a condition of tentative tract map approval."

Location and form

One person who has been working with problems of solar access for many years now is Ralph L. Knowles, University Professor of Architecture at the University of Southern California in Los Angeles. He believes that existing development may be too locked in to allow much more than conservation measures and limited use of rooftop collectors where there is sufficient sun. But he also believes that as transformational growth occurs over time in such places, great benefit can be derived from an understanding of the principles of location and form, which are the keys to his solar design methodology.

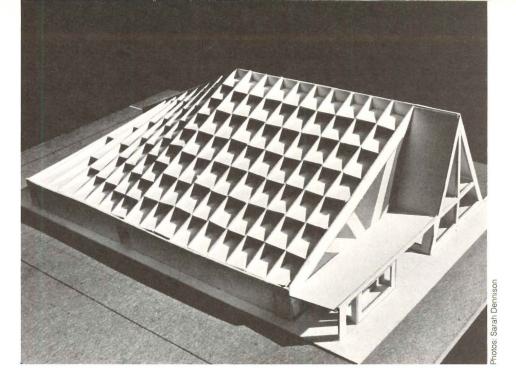
Working with architecture professor Richard D. Berry and the USC students, with funding from the National Endowment for the Arts, Knowles directs the only solar-access design research project in the U.S. Although he fully recognizes the potential inherent in the use of solar energy for generating disputes between property owners, Knowles is nevertheless firmly committed to the idea that "anybody seriously concerned with future policies and designs governing building must consider

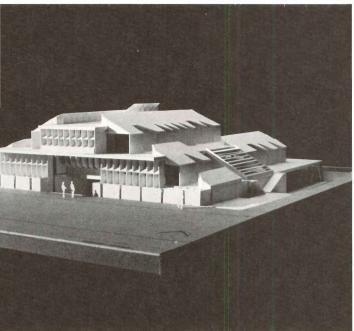


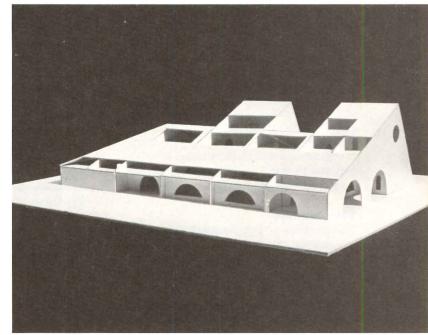
solar energy as a way to temper the constructed environment." He asks, can potential conflicts between users of solar energy and other property owners be resolved? Can solutions be designed initially in a manner to avoid future problems?

In looking for precedents where the construction of buildings or communities reflected an awareness of the value of the sun for tempering the built environment, Knowles had no success in the grid-plan culture of America. He did, however, find American Indian settlements where construction had been carefully guided by solar ethic (these are fully documented in his extraordinary book Energy and Form: An Ecological Approach to Urban Growth; MIT Press, 1974). At Acoma Pueblo in New Mexico, for instance, Knowles writes of the typical stepped-back, south-facing terraced rowhousing. Low winter sun enters the windows at each level to provide interior illumination, and its heat is also absorbed and stored in the thick masonry walls to be released to the interior at night. The high summer sun strikes roofs of timber, reed, and grass, which act to insulate the interior from heat (illus. 1). In addition, the house rows are separated so that one never shades another in winter; and where houses are higher, streets between rows are wider (illus. 2).

In the academic years of 1977 and 1978, USC students designed retail, office, and residential projects conforming to the solar envelope. Shown here are: Paul Bodine's retail building, view from north-west (right); Tom Chessum's office building, view from south-east (middle left); Armando Caballero's retail building, view from north-west (middle right); Ines Gomez' housing, view from south-west (bottom left); and Paula Waller's housing, view from south (bottom right).











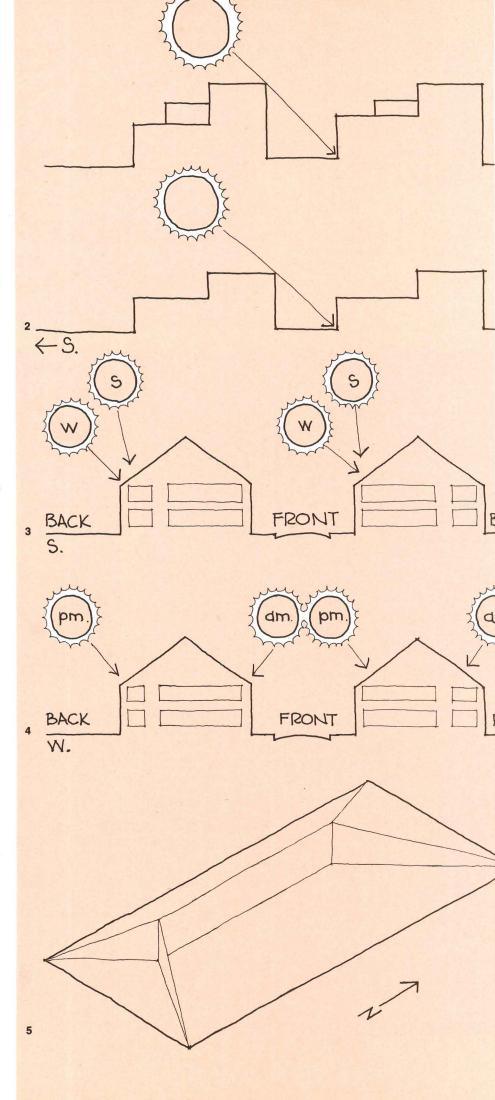
Ralph Knowles's solar envelope

The typical American community, however, shows no organization in which the location and form of buildings express modes of adaption to the sun. Instead, orientation is toward the street where, often in contradictory fashion, the sun strikes the house without regard to its interior organization of public, private, and service spaces. A house on an east-west street, for instance, is affected critically by the sun, on a seasonal cycle, at its front or back, depending upon which side of the street it is on (illus. 3). The front or back of a house on a north-south street, however, is affected critically on a daily basis, either in the morning or afternoon, depending upon the side of the street the house is on (illus. 4). But even if a house is organized and designed to take maximum advantage of the sun's variations, there would still exist the problems of shadows both cast on and cast by the house.

Solar envelope

Can buildings be designed so that each respects the accessibility of others to solar light? Can no property owner be victim or victimizer? These are the questions Knowles really asks. In seeking solutions to the problems of shading, he, Berry, and the design students at USC have devised a solar envelope, which is defined as "the largest volumetric container over a land parcel that allows solar access to all adjacent neighbors within useful time constraints (illus. 5)." They took Los Angeles, at 34 degrees north latitude, during the hours from 9 a.m. to 3 p.m. in the winter and from 7 a.m. to 5 p.m. in the summer, as their model. They then worked with a helidon (a "sun machine") to trace the sun's movements during the critical extremes of the winter and summer solstices. By shining its moving light over a hypothetical lot arranged with the vertical planes representing the upper limits of volume, they could determine by shadowing where and to what degree the proposed volume was insufficient or overextended. This method also made the relationship between land parcel orientation and shadowing immediately clear, since depending upon how a parcel was oriented, the sun's major effect on it would occur either at daily or seasonal cycles (illus. 6).

As an experiment in the summer of

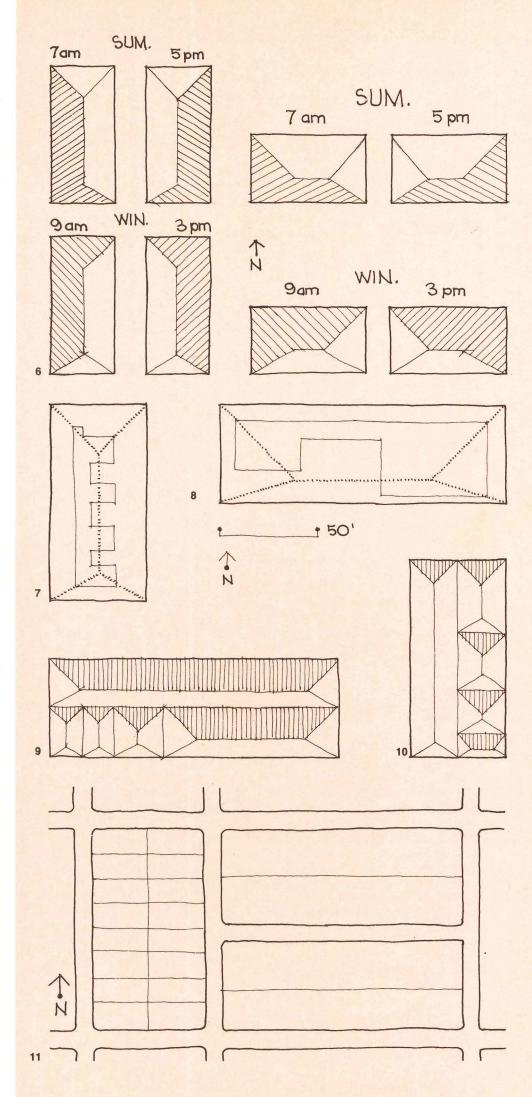


1977, the USC group decided to work out a 2000-sq-ft single-family house on a 50' x 150' lot that ran deep in the north-south direction. This would not have been much of a challenge had they not confined themselves to the lot's solar envelope, which was 121/2' high, and had they not attempted to gain adequate south exposure. The resulting volume, however, presented an awkward arrangement of segmented spaces, and it also allowed no large yard (illus. 7). On the other hand, the same size house on the same size lot oriented in the east-west direction had the combined advantage of 30 percent more envelope height, good organization of volumes, a large yard, and greater south exposure (illus. 8). In the 1977 and 1978 academic years, the students expanded their work with the solar envelope to include projects for a small retail store, an office building, and housing, some of which are shown here (p. 77).

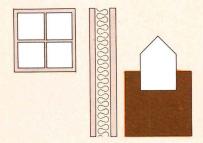
Solar envelope and land assemblage

The value of the solar envelope is not restricted to the single building, however, since the method can also be used advantageously in land assemblage. Knowles has shown, for example, that narrow lots running deep in the north-south direction on east-west streets have no south advantage. But as land assemblage accumulates more parcels, orientation shifts to the south and gives that advantage (illus. 9). Conversely, because small lots facing north-south streets already have their major exposure to the south, land assemblage is disadvantageous (illus. 10). Contrary to conventional wisdom then, land assemblage is not always the best course, but would only be of advantage for parcels long in the east-west direction. Knowles believes that not only with new development, but also in urban transformational growth, zoning policies could be developed that recognize these essential differences of block orientation (illus. 11). For existing urban situations, he says, renovation and retrofitting of older houses may be the best solution under one set of orientation conditions, while land assemblage and a change of land use may be better under other conditions.

There seems to be little question that application of the principles of the solar envelope could make better use of the sun for energy conversion and life quality. But the question of one's right to access to the sun is a legal question. Putting the methods of the solar envelope into use as a lawful zoning mechanism, Knowles explains, is possible only to the extent that access to the sun can be considered a basic right. As of now it is not. But until recently for many of the handicapped and disabled, neither was the right of accessibility to buildings. [David Morton]



Reduce the load: The building as a heat exchanger



What follows is part one of an extensive interview of Fred Dubin by Richard Rush. An internationally famous engineer talks of a full range of opportunities open to us to conserve energy with passive design.

When we talk about energy, there are always people who think the problem doesn't exist. If anything comes out of this magazine, I would like the architect who has been skeptical about energy to come away with an understanding of the importance of energy consciousness in design, with or without Arab oil and with or without solar energy. We want to show the skeptic that he doesn't have to be a mechanical engineer to design a building that is energy efficient. I am afraid, however, that the vast majority of architects in this country wish the whole problem would go away.

I would like to stress the symbiotic relationship of design, construction, materials, microclimate, building configuration, maintenance, energy supply, the passive, and the active systems; they are all parts of the total microcosm. Energy-conscious design means that the building structure will enhance the use of natural energy sources when available and provide a barrier to the external environment when it is hostile. The mechanical and electrical systems will require the least amount of energy per unit of work performed, and the building will be adaptable to accommodate developing technologies as they become available in the future.

When you talk to architects, what are the major areas of resistance to energy-conscious design?

Inertia. Lack of awareness, ignorance of the interrelationship between the climate, the site, the behavior of the building materials, the dynamics. These important rela-

tionships affect function, comfort, energy use and cost; but the cost of assessing these relationships is not covered by the conventional fee structure of a specific project. A lot of extra effort, study, digging, and research are required for energyconscious design. Another big impediment is that the client often doesn't care what happens either with energy or economics 15 years down the line. The architect doesn't prepare himself because he feels that no one will listen to him anyway. My feeling is that the professional designer must first prepare himself and then find those clients who will listen. And they can't listen to you if you don't present facts. We must each make a personal investment in knowledge and then educate clients. I think society will come along with us. A profession implies public service and leadership as well as competence.

A small architect who is busy these days will most likely say he does not have the time to educate himself and cannot afford a Fred Dubin.

It does not take all that much time to learn the principles; the small architect sets his own priorities. He can find time for short courses, reading, or a couple of hours with a consultant. A consultant would do it. We do it. It gives the architect and the client direction. There is no excuse for not building up a good library of resources, reading materials, case histories, guidelines. Local and regional conferences provide an architect a chance to listen to and meet qualified consultants. The American Consulting Engineering Council provides lists of qualified energy management consultants.

That boils down to something very important—selectivity. There are basic principles which apply, but then one must be selective whether it is building type, system type, materials, local climate, re-

gional characteristics, or selecting a consultant. Two things stand out very clearly to me: selectivity and programming, and they go together. An energy program interfaces with and is an essential element of the building program, interfacing with other elements, i.e., function, space requirements, cost, reliability, safety, aesthetic quality—and more. We have some goals now pertaining to energy use. The question is, how do we attain them. I like to have an end energy-use goal for the entire building and a target goal for each individual system and subsystem.

One of the very first things we do in promulgating an energy program is to set the internal conditions: how much space for each occupant, how much ventilation, what air quality, what temperature and humidity for each space with differing occupancy and activity. Those are all in the energy program. They are very, very important.

What guidelines do you use for setting up an energy program?

For each particular building type we ask ourselves: do we want to maintain the building temperature at 68 F in the winter and operate air conditioning at night during the summer? Are we allowing smoking in the building? If so, are we going to limit smoking to areas with increased ventilation? These are all part of the energy program and each building type will have its own special requirements. Much of an energy program is established by knowledge gained from experience, judgment, and often by codes. A well-written energy program for the building can yield an overall maximum permissible annual Btu count per sq ft. The energy program leads to the next step—selectivity. One begins to look at the specific performance of each building component: the roof, the walls, the fenestration, the lighting, the prime

movers, and all components of the energy distribution systems.

What does such a program look like?

The energy program first sets the environmental conditions to be maintained in each area of the building, the amount of energy to be used per year or per season, the peak demand or peak load, and the limiting of the peak loads. There are broad categories and then disaggregated subsystems. A written energy program is a very useful device with which to communicate between the architect, the engineer, and the client—a document which lists the objectives and details the paths to follow to meet the objectives. It does not die there; it is modified continually during design development and continues to the final specifications. Trade-offs will be required, with each decision based on comparative performance, cost, and end goals.

That leads to your idea for a library.

Yes. We need a library of energy systems, an inventory of energy systems and building components indicating the energy dynamics for different types and construction of walls, windows, roofs, and other building components—walls, with or without mass, and the insulation type and location, all for different climates. We would not need to do a separate, involved, computer analysis for every building. Once one is through with the bubblediagram phase of spatial relationships, he could retrieve energy performance criteria for materials and systems for the library. Anyone designing a building can then say, "Okay, I have a choice of materials and each alternative is going to cost 'x' Btu per sq ft, depending upon my selection of the building component and its dynamic interaction with the climate and selected mechanical and electrical systems." The library of systems can provide the means to determine the energy demand of each system and component for every square foot of building. Your energy budget is in one hand and the inventory of parts is in the other. You enter the library which contains the information on how the different parts interact dynamically and what they cost in Btu.

Let's concentrate on the basic thermodynamic principles which architects can relate to designing their buildings as "heat exchangers." How do the strategies in different parts of the country differ for energy conservation?

First of all we must look at the whole picture. You may have more degree days in a colder climate than in a more southerly location, but the colder area may have more

sunshine in the winter and therefore be less energy intensive, with proper design, than a building in an area with fewer degree days but with less solar radiation. You cannot take any one element by itself. The amounts of sunshine, wind, and degree days all affect the design loads. When winter sunshine is more abundant, a larger south-facing façade with glazing and internal mass can result in less energy consumption than a windowless south façade—but the relationship between glazing, winter heat loss, summer heat gain, and natural illumination must be identified in order to optimize energy conservation through design. The amount of sunshine alone is not enough to make a solar system cost effective. The competitive conventional fuel situation also plays a major role. New York does not have as much solar radiation as Arizona, but higher fuel prices make solar heating more cost effective in New York. Every good design always comes back to the micro situa-

What areas of the country comprise the best and worst ends of the spectrum for energy-conscious design?

A building with a large internal load may be more energy efficient in a cold climate, like Minnesota. If the external load is determining energy usage, it is most effective where extreme hot or cold temperatures are not encountered, like San Diego.

In terms of energy conservation, what areas are the worst for energy conservation?

I think some areas along the Gulf—in Houston, Tx, for instance, one can hardly exist comfortably without air conditioning. It gets very hot; also cold and humid. So that is one location that inherently requires a great deal of energy. Another example is a very cold climate when there is no large internal building load. It is easier to control energy usage in the North than in the South. In cold climates, insulation, control of ventilation and infiltration, and building mass can reduce heat loss. In hot and humid climates, it is harder to control heat gain. Outdoor air is probably the largest single factor in causing energy to be used. Infiltration or air introduced for ventilation must be heated, often humidified, or cooled and dehumidified. Building construction to reduce infiltration and selective ventilation keyed to occupancy are necessary to control those loads.

How do the characteristics of a particular site affect energy design.

Greatly. A site at the foot of a mountain usually experiences greater diurnal temp-

erature swings than a site on a plain. Diurnal swing can be used to provide natural cooling in climates like Albuquerque, Denver, or Sacramento. Trees and shrubs can provide wind breaks to reduce heat loss, or to channel summer breezes for natural cooling. Orientation can affect the useful or negative effects of solar radiation depending upon the season. Bodies of water can provide ambient cooling, or a heat source or sink for mechanical heat pump systems. The topographical characteristics can be utilized often to control the climatic effects on building structure. Earth available for berming can be used effectively to stabilize external temperature variations on the building structure. Subsurface conditions can affect the building configuration, the utilities distribution, and the ability to provide partial or complete underground construction.

What site potential do you look for in an underground building?

Subsurface conditions such as soil characteristics, water table, and earth temperatures. The differential between average outdoor and earth temperatures in summer and winter. Light must be brought into the underground building, and buildings with high internal loads cannot dissipate heat so readily in underground structues. However, in very hot or very cold climates, underground structures can be very energy efficient. It is generally more costly to construct underground than it is above ground.

How do landscape architects use the energy characteristics of the site?

There are many qualified landscape architects and engineers who, working with an energy management consultant, are very knowledgeable as to which plantings are most effective for solar control while letting summer breezes work through their lacy, gauzy branches. They know which plantings grow fast given the local soil and precipitation data; which plants divert winds; how far from the building to plant to direct air and wind over or through the building as the need dictates.

One of the problems of course is that we don't always know the exact conditions that exist at a site. The wind information from the airport may not be accurate for the site. We found this to be true in Nairobi, Kenya. We have readings there from the weather station five miles away from the site; readings at the site itself differ. With a small weather station neatly placed on the site, short-term collection data can be compared to longer term, more remote collection data, and a comparison between the two can be made to project what the long-term data at the site might be.

Passive general conservation

What should be measured?

The average velocity and direction of the wind for each month, with the hours that each condition prevails; the wet- and drybulb temperatures for each month—maximum, average maximum, minimum, average minimum, for daytime and night time; average direct and diffuse solar radiation, and precipitation; also, the cyclic nature of cloud cover and temperatures on a weekly basis.

What are we talking about in terms of price of equipment?

That depends on how sophisticated it is, and whether you collect long-term data or not. We designed a weather station for a campus site in Iran that was pretty sophisticated and cost \$10,000. The price, I would say, can vary from \$3–4 thousand to \$10 thousand. For a whole campus of \$1 million to \$100 million of construction, spending \$10 thousand for accurate measurements is not a luxury or a frill.

Based upon your site and your weather characteristics, there will be an effect on the shape of the building, its orientation, and materials. What are these effects?

First of all, heavy winds on a building increase the heat loss. The effect is even more pronounced on glass and thin panel walls than it is on heavy walls. Wind sweeps away the outside thin layer of air, so with heavy winds you have, in effect, removed one of the building materials. If you have a thick wall and the U-factor is such that the outside thin layer of air is a small percentage of the total, the wind effect is not so critical. It may mean, for example, that you eliminate the windows on the windward side of the building or provide wind breaks. The second consideration is natural ventilation. If you want the air to pass or be drawn through your building, you must orient it and adjust its shell accordingly or provide planting to influence wind pattern. The other effect of the wind is that it might create a very dusty climate and have an effect on available solar radiation.

What about the orientation of the building with respect to the sun?

You must know where the sun is and where the wind is at all times, so you can decide: do you want sun or heat or don't you? In the winter, a southern exposure gets more of the sun—more than the east or west exposures. The east and west are the hardest to shade in the summertime.

Today we are much more conscious of trying to use the winter sun in cold climates for natural heating.

Which building forms are most susceptible to large energy use considerations?

Of course it depends on the climate and whether the lighting load, heating load, or cooling load dominates. An all-glass building is generally more energy intensive than one with a more judicial use of glazing, regardless of area and location. High-rise buildings have less roof heat loss and heat gain, but experience greater wind velocity and more heat loss through the walls.

When do you want a building with minimal exterior surface and when do you want to maximize the surface?

Well, if we want to reduce heat loss, then clustering and common party walls with minimal glazing on the west and north façades is an answer. If there are large internal loads, you may want more surface to dissipate heat. If you want to maximize natural illumination, then you want more exterior surface whether it comes from an atrium space or the exterior building envelope. Atriums are a very effective energy saver for providing light to the interior of a building. By using an atrium you can have a tighter plan and still have more exposure for natural illumination without the penalty of high heat loss or heat gain. You can close up an exposure that has a brutal exterior environment and open the building to a controlled interior. A multi-use atrium used for circulation space, unconditioned, can result in a higher utilization space within the heavily occupied building zones, and the atrium provides light and a controlled environment on the adjacent surfaces. Often we bring outdoor air through the atrium to be prewarmed by the sun; we are pretempering the outdoor air and reducing air-conditioning costs.

Skylights are a source of energy loss as well as energy gain, just like windows. How do they perform?

Skylights can be designed to face whatever direction you want to bring in light. They can be operable and allow natural ventilation through them. They can be protected from direct sunlight, or used for direct heat gain by allowing the sun to come in and strike a mass wall. They can be protected from heat loss at night by thermal barriers.

Are we talking about multiple glazing?

Well, you can use multiple glazing to cut summer heat gain, or to cut heat loss in winter and prevent condensation. When you start putting holes in the top of the building, you must deal with the fact that heated air rises, whereas, if you put holes in the side of the building, you are not dealing with that problem directly. Maybe we could talk about the role of windows.

On the positive side, windows provide a view of the outdoors and furnish natural illumination and natural ventilation. On the other side of the coin, windows increase heat loss in the winter by conduction and through infiltration, and increase heat gain and cooling load through conduction, solar radiation, and infiltration. Window design and location must be carefully analyzed to optimize energy conservation considering the many benefits and many liability potentials. Windows, properly treated for control of summer heat-gain and glare can provide most of the illumination needed during daylight hours with minimum energy input. Windows, especially in the south façade or in clerestories, are the major apertures to use passive solar heating effectively. Operable windows can provide natural ventilation and reduce air-conditioning requirements for much of the year in many climatic zones, and windows can effectively dissipate excess internal heat gain and reduce airconditioning requirements. But the relationship of the window size, type, and placement in each building to heat gain, heat loss, and infiltration must be thoroughly understood and quantified.

Why do we want the window? Do we want it for light, for view, or for air? We don't put the window in the same place for all those functions, nor do we use the same kind of window. By the correct positioning, we might reduce the window area by half without any reduction in the natural illumination, but with 50 percent reduction in heat loss.

Windows can be a net positive gain in energy conservation if they face the right way, if they are properly protected, if they don't produce glare and excess heat, and if they have a thermal shutter (particularly in cold climates) to shut them off at night when there is no view and no light.

When is the use of special glass appropriate?

We use special glass for three reasons: (1) to cut down on unwanted direct solar heat gain; (2) to reduce glare; and (3) to reduce heat loss. If an architect wants to build a sheer façade, he must do something to reduce heat gain. He needs reflective glass. Heat absorbing glass is not so effective but let's not build sheer façades.

Isn't it conceivable that reflective glass is a cheaper way to build an office building than installing all the sunshields? Yes, possibly first cost. But not always —not when the life-cycle cost and cost/benefits of each system are considered.

What about Beadwall?

Beadwall is an ingenious idea and Steve Baer is to be congratulated. The concept is fine. It is changeable insulation. It is really what we are looking for—to have the material meet changing needs. It has limitations, however: it requires pipes to deliver the beads; the walls and windows must be constructed to accommodate the beads. It can be very effectively used in a greenhouse, where the night loss must be controlled. Also, there are other approaches for movable insulation such as insulated sliding panels, laminated insulated shades, and other types of thermal barriers which can be manually or automatically controlled.

Plastics can be used for the greenhouse effect, and as replacements for glass in the sense that you might want the air and the light but not the view.

If you want light and not view, plastic can be cheaper than glass.

When you get into plastic you could also be getting into color. Let's go to the other surfaces of the building—just the surface—and talk about color. How much of a role does color play?

On exterior surfaces color can increase or decrease absorption or emission of heat. Color, texture, and mass are interrelated.

Are we likely, in the future, to find buildings with outside walls with different colors depending upon their orientation?

That would make sense. It makes sense to have highly reflective surfaces in hot, sun-warmed climates.

We can expect to see the soffits painted different colors from the walls?

Yes, you can reflect a great deal of light into the building. Roof color is also very important. In the summer you want high reflectivity and a light color; in the winter you want dark colors. The climate governs.

Now let's get into the wall itself. I suppose the major subjects are the mass and the resistance. What are the situations where the resistance of a wall is the prime consideration?

Generally the mass is more effective with ventilation and with temperature changes; the short environmental swing. If

there are large swings, and if you are in a climate that is relatively humid and has fairly constant temperatures, the mass doesn't do much good. The amount of insulation, the thickness, type, R-value, costs—most people pay attention to these factors. We also look at the shrinkage characteristics and fire retardant qualities of the material. We are very careful to isolate all forms of insulation from moisture. Moisture can ruin the insulation value of a material. Good roof insulation is critical for controlling heat loss and heat gain. We rarely insulate a wall just to lower heat gain in the summer.

Which are the most important elements of the evaluation of insulation?

Well, the R-value is of course number one. Next is the integrity of the material, whether it shrinks or settles, and how it works under the dynamics of heating and cooling. Third, will it absorb moisture or not? Methods of installation and physical dimensions must be considered.

What warnings or rules of thumb do you have about U-value that you could give to architects?

Well, one suggestion is that the U-value be calculated for specific conditions rather than just taken out of a handbook. The U-value changes with the presence of wind as well as moisture. If we put insulation on the exterior of buildings, we may have moisture in contact with insulation if it isn't properly protected. There is a lot of judgment involved. Also I would suggest that the U-value be calculated depending on the kind of heating device in the space. If, for example, the U-value is given as .10, that assumes, for instance, a 15-mph wind or whatever on the outside, and dead air on the inside. That would be okay if there is no heating device below the glass. If we place a radiator or an air duct below the window or wall, we blow warm air vertically; first, we have lost our thin film, and second, we have a temperature difference—not between 70 F in the room and 0 Foutdoors—but it might be 100 F on the inside meaning a larger temperature difference and greater heat loss. These subtleties must be taken into account and can make quite a difference in annual heat loss through the envelope.

Let's talk about thermal mass.

I would like to talk about the combination of color, mass, and insulation. There is no question that if you have a large internal load—for instance, a high lighting load—the mass inside the building in the summertime could be very useful to absorb internal load generated by lights, ma-

chines, people, or solar heat gain. At night we get rid of the heat by circulating cool night air in the building. In that case you definitely want the insulation on the outside. If we use the mass to absorb the lighting load, it may not enter the cooling load at all, because we can remove the heat with cool night air. Very often, however, we can't bring the night air into the building because it is too humid and it condenses on the cold surfaces.

How about cold climates?

The idea is to bring the sun into the building, store excess heat in the mass, and let it discharge into the space at a later time. If there is no internal load and not much solar heat, the mass wouldn't do as much good. It may be counterproductive. The mass cools, and then you must raise the air temperature in order to be comfortable, to compensate for the cooling effect of the body radiating heat to the cool surface. From a comfort viewpoint, the insulation on the inside may be preferable but not energywise. For instance, in a church. the space is not heated all week in winter. and it is uncomfortable sitting next to that cold surface on Sunday even with warm air delivered into the space.

When can infiltration, window frames, door frames, joints, and details be problems?

Attention to detailing is lacking very much of the time. There is a lot more leakage than we calculate for. Poor workmanship, leading to excessive infiltration, and shrinkage of materials can account for as much as 30 percent of the heat loss in a cold climate. Many of the windows are metal through and through, and if there is no thermal barrier within the window frame itself, high conductive losses result. Infiltration can be a large factor in cooling as well. In the summer, leakage of warm, moist air into the building creates a cooling load due to the dehumidification and sensible heat gain load. In tall buildings, stack action from elevator shafts can induce large amounts of unwanted outside air.

How can we eliminate entry losses and improve door construction?

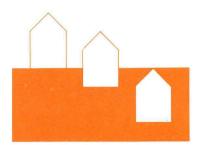
The location of the door is very important. Doors should not be on windward sides of the building. Air locks can be very effective. Revolving doors are also effective to reduce infiltration and heat load. We are using magnetic weather strips on outside doors. Of course we want door closers. Glass in a door is the same as glass in the window. Double glass can be cost effective in a door and doors can certainly be insulated.

[continued on p. 88]

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Up to earth

William Morgan, FAIA

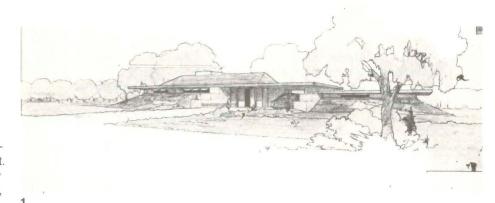


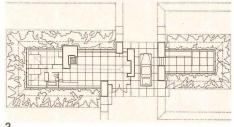
American architects have already had long and beautiful experience carving economical spaces out of a material that is always available, dirt cheap.

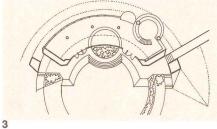
For thousands of years man has been using the earth to shape his environment. When properly used, earth is strong, durable, and easily rendered weather resistant. In view of growing concerns about energy conservation, environmental preservation, depletion of natural resources, and pollution—including particularly visual pollution—it may be helpful to review several examples of earth-related architecture in the United States over the past 40 years. The examples shown on these two pages were designed before the energy crisis developed. They celebrate design rather than technology, but like all significant design they use technology well.

In 1942, Frank Lloyd Wright designed the Cooperative Homesteads 1, 2. (The Keyes House in Rochester, Mn, is an example completed nine years later.) Wright cited these advantages of using earth berms: good insulation against the elements; ease of placing earth against walls with a bulldozer; economy of not having to finish exterior walls below windowsill height; preservation of the landscape. Wright also provided extensive overhangs that minimize rain saturation of berms, reducing hydrostatic pressure against walls. Continuous horizontal windows, shaded by these overhangs, provided appropriate light and ventilation.

Another example of Wright's berm construction is the second Herbert A. Jacobs house in Middleton, Wi, 1942, one of his most compelling designs with earth **3–5.** Wright created a circular terrace, recessed slightly below grade, and placed a curved, two-story residence along its north side. A berm is placed against the outer side of the house for insulation and to de-



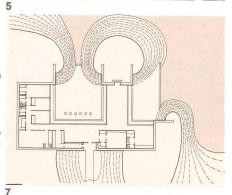












flect cold north winds over house and terrace. The curved south wall is glazed to admit maximum winter sun and provide a view of the rolling terrain to the south. As one approaches the house from the north, it seems to be a natural hill. At the easterly end, one enters through the berm 4 around a massive stone end-wall, and into the living area, with bedrooms on the open balcony above it. Extended overhangs protect the glass walls from summer sun; the curve of the house blocks out summer sun in early morning and late afternoon.

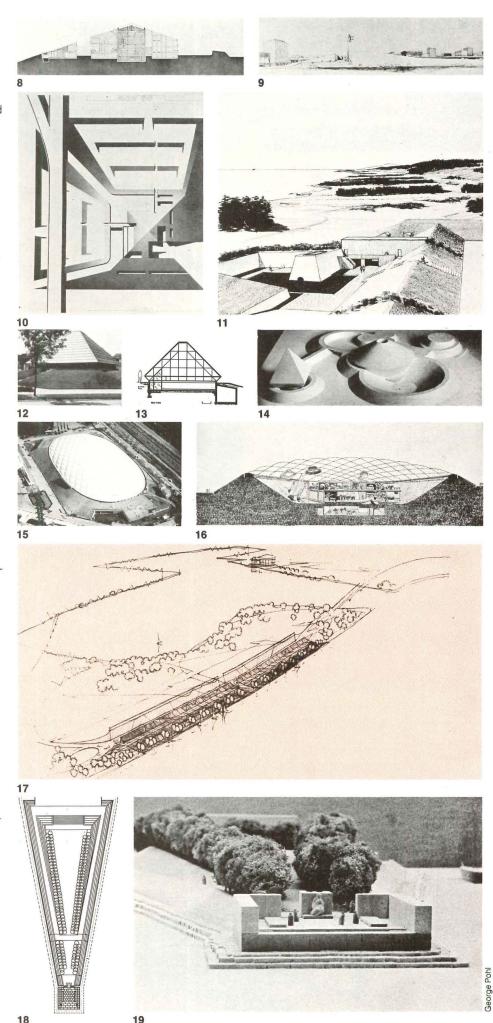
In 1965, Philip Johnson set the Geier House **6, 7** into a suburban lakeside field near Cincinnati. Here Johnson created an inward-focusing environment, with privacy from the public road to the south and from neighboring structures. The floor slab is barely above the level of the lake. A gentle valley guides the visitor to the clearly stated entrance. Concrete wall and roof slabs are insulated with 2 in. of foamglass and 15 in. of earth on the roof. In 1966, Johnson completed his underground museum, a few hundred feet from his Glass House in New Canaan, Ct.

Charles Moore's 1966 design for a City Hall and Emergency Operating Center for Tortilla, an imaginary city in the Southwest (a design problem sponsored by Civil Defense authorities) took the form of an asymmetrical pyramid 8-10. The design integrates parking terraces and vehicular and pedestrian access into a single urban-scaled form. A second, largescaled earthwork by Moore and his associates, with Lawrence Halprin, is the Athletic Club 11 for Sea Ranch, designed in 1965 and completed soon after. Here earth berms allow a relatively small building to be unified in a single composition with larger-scaled pool and tennis courts, the whole protected against chilly coastal winds.

In a branch bank in Fort Wayne, In **12**, **13** George Nelson used simple earth berms and a pyramidal roof to identify a small institutional building in a chaotic asphalt environment. Within the berms, Nelson recessed storage and toilet rooms, leaving an uncluttered interior space (P/A, Nov. 1971, p. 115). Nelson's 1968 proposal for the U.S. Pavilion at Osaka **14** used economical cut and fill to create a variety of exhibition areas and a park.

The actual U.S. Pavilion at Expo '70 in Osaka **15, 16** by Davis Brody Associates, Architects, and Chermayeff, Geismar, and deHarak, consisted of a 260' x 470' space, descending three levels inside an earth-berm ring, covered by an inflated, cable-restrained fabric roof. This design was developed after a budget reduction ruled out a taller air-supported scheme.

Robert Venturi's 1960 proposal for the FDR Memorial 17, designed with John Rauch and others, envisioned a series of



20 24 28

Earth architecture

linear elements parallel to the Potomac—a widened drive flanked by earth embankments, through which several portals gave access to a broad, tree-lined riverside promenade. The compelling design was very much in scale with Washington's vast axes, recognizing the presence of the existing Lincoln Memorial and Jefferson Memorial without heroic gestures. Lawrence Halprin's current scheme for the FDR Memorial also employs earth elements.

Louis Kahn's 1973 design for the FDR Memorial on Roosevelt Island in New York 18, 19 consisted of a tree-lined garden set on an elongated trapezoid of earth and a granite-walled "room" at the south tip of the island. Earth and trees were dominant elements in this sensitive conception.

The following projects illustrate some of the author's experience with earth in recent years. The Florida State Museum **20**, **21** was completed in 1971 for about \$21 per sq ft. Earth ramps give vehicular access to each of its three levels, eliminating the need for elevators. Air conditioning is not required in the extensive below-grade storage areas because the surrounding earth maintains a year-round temperature of 69 F; minimum humidity control has been required. The museum operates at 38 percent of the energy cost per sq ft of nearby University of Florida buildings.

For a 6000-seat amphitheater on North Biscayne Bay in Miami **22, 23** an artificial hill was proposed. Broad earth ramps gave access to seating above staging areas, exhibition spaces, and restaurants. A 220' x 550' tensile roof of Teflon-coated fiberglass protected the audience.

A maintenance facility for the U.S. Fish and Wildlife Service in Southeast Georgia **24, 25** combines offices, storage, and equipment-maintenance sheds into a single building anchored by earth berms. Nearby seasonal quarters **26, 27** consist of four one-bedroom apartments, with earth-berm insulation and through ventilation; central fireplaces supplement winter heating and support roofs. Here, earth is used to establish a sense of place for structures of disparate function in a remote woodland setting.

Regional offices for a national corporation in Altamonte Springs, Fl 28 integrate a berm-enclosed parking area with a two-story office structure on a sloping site. The truncated earth-walled structure takes account of the increasingly cluttered highway bounding the site.

The Perdue Office Building **29, 30** was designed for a small valley between two hills near Salisbury, Md. An artificial lake to the north provided fill; parking areas are concealed by berms to the south. Natural light is introduced to the building through

slots in the east and west slopes, through skylights, and under extended overhangs to the north and south. New trees placed on the earth-insulated roof were placed in planters directly over concrete columns to confine stresses to simple compression. Construction costs are similar to abovegrade buildings.

The Hilltop House in Central Florida **31**, **32** is a two-story residence recessed into the earth, with an open pavilion above. Vehicular access to the lower floor entry and berm-enclosed garage suggests entering a volcano crater. The structure is developed within—rather than on—the hill.

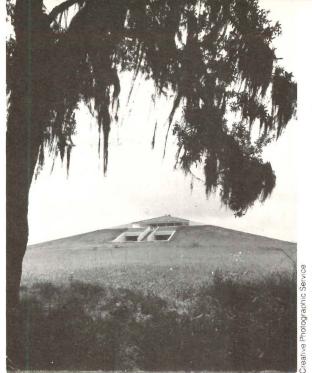
The recently completed Dickinson house **33–36** near Gainesville, FI, is a reinforced-concrete block walled structure. Slightly recessed into the east hillside to develop fill for berms, the house opens onto a screened porch and swimming pool oriented due south **34.** Light and ventilation scoops define the corners of the house, and a central fireplace mass supports the roof. A white-columned covered walk linking the house to the bermed garage forms a clearly visible entry link, leading to a skylighted entrance door **35, 36.**

The Amelia Island Dunehouses **37** were recessed into existing dunes, stabilized by a dense oak forest. The structures have reinforced-concrete block walls with precast roofs; wood floor framing was designed to resist inward pressures of earth on the sidewalls. Construction costs were similar to conventional units.

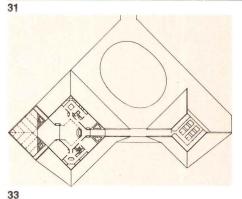
In the Atlantic Beach Dunehouses **38, 39** walls and roof became a continuous concrete shell resolving all stresses in compression and relying on earth fill for post-tensioning (P/A, May 1978, pp. 108–109). Water-cooled air conditioners effectively control humidity in the apartments, which require almost no temperature adjustments because of earth insulation 22 in. or more in thickness.

After reviewing the foregoing examples, the reader may wonder why broader interest has not been shown in this possibility—particularly in view of our growing energy and environmental concerns. I believe that awareness of the earth's architectural potential is increasing slowly, as indicated by recent articles, books, and exhibitions, and by inquiries that reach my office. As more examples of earth-related architecture become available to the public—and as fresh approaches to such design emerge—we may expect to see earth-related structures gain wider acceptance.

This is not to suggest that earth architecture is an appropriate solution to every problem—nor that the future of earth as a building material is solely a function of energy awareness. But man's almost forgotten tradition of earth architecture may now be on the verge of reevaluation. □





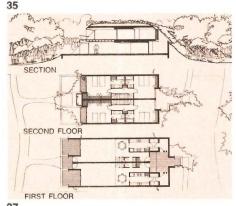




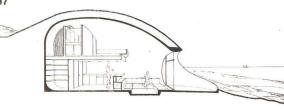




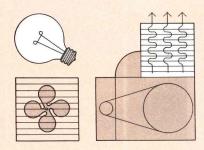




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Meet the load: Mechanical matches



Fred Dubin further discusses the topic of energy conserving with Richard Rush. In part two of the interview, the subject is mechanical means of meeting the load.

Probably the largest barrier facing good energy-conscious design is the architect's innate mistrust of the nonvisual mechanical world which goes on behind the scenes in a building. He must understand the analytical principles involved with mechanical systems and their ramifications on his building, but he must rely on the mechanical engineer for the calculations and the mechanical design. As energy becomes more central in its role in design, the relationship between the two professions must change. How has your role as a mechanical engineer changed in recent years?

Ten to 15 years ago we were rarely called in by the architect at the inception of building design—and we were retained for the most part by the architect. Generally, he had completed preliminary plans and then asked us to calculate heating, ventilating, and power loads; select systems within certain budgetary and physical constraints; and determine equipment-room spaces, duct and pipe chase locations and sizes. Too often we were asked to "shoe horn" mechanical equipment into predetermined (by the architect) spaces.

Now, the role between architect and engineer is more true collaboration. Engineering starts with building programming. We are providing extended services, including analysis of site, building configuration and materials, and other factors which were solely the architect's prerogatives in former days. In order to reduce annual energy consumption, as well as peak loads, and provide mechanical and electrical systems which are compatible with the building program, the engineer is often selected by the owner at the

same time as, or even in some cases prior to, the selection of the architect. We are with increasing frequency retained by the owner as well as the architect to provide energy-management services and perform mechanical and electrical design.

In the last five years, the architect has begun to think and speak thermodynamics. It is also true that more and more engineers are speaking and thinking architecture. You have an architectural degree now. How has your attitude changed?

I find that my views are more often accepted by architects. I think I understand his problems better now—I speak his language as you said. But it has not changed my attitude a bit. It has only reinforced it. It is also true that the architect is becoming more sophisticated in his understanding of energy relationships. For passive solar heating or cooling the architect and engineer are teaming up to produce a sophisticated design approach to accomplish a deceptively simple solution for energy-conscious design.

How consistent is the quality of the energy consultants which architects are likely to employ?

Unfortunately there are some people acting as consultants today who do not have the background and knowledge of either building or mechanical systems. The best assurance of accomplishing good performance in energy-conscious design is to know that you have picked the right consultant who has had extensive building and engineering design experience for that specific building type. He must know the design procedure as well as the proper operational procedures. After the building is built, accurate feedback on performance is very difficult to obtain, so it is important to design properly from inception.

Then the basic reason for the energy program is as a design tool, not to evaluate the success or failure of the final building?

Yes. The energy program must precede design. The program includes early design equipment and materials guidelines to meet the target energy-use goals. The program is the document which can be understood by architect, engineer, owner, contractor, or occupant and tenant so that each is aware of the end goals and the means to accomplish them. The program is not a static one, but must be changed, if necessary, as design progresses and feedback determines the cost-effective implications of the early decisions. The performance of the completed building can be compared to the energy program for evaluating compliance with the program or for modifying the program for future projects.

I want to stress that the basic principles of energy-conscious design—the building form (materials and parts)—are the first line of defense against lifelong excessive energy consumption and peak demand. Passive heating and cooling are the second line of defense. Active solar and alternative energy sources are the third line; and finally the back-up is efficient mechanical and electrical systems at full and part load conditions to handle the residual loads.

What are the basics of energy conservation for the heating equipment?

First, a detailed analysis must be made of the duration and the magnitude of specific load increments and their percentage of full load conditions. The short cycling of equipment also increases energy usage. It is preferable to have smaller equipment that runs steadily than to use larger equipment that turns on and off repeatedly. Both the equipment and the

combustion devices operate most efficiently. For instance, how many hours does the full heating load occur? How many hours does each of 90 percent, 80 percent, 70 percent, 60 percent, 50 percent, and lower of the full load occur? The answers to such questions help select either a single piece of equipment, or preferably modular equipment with proper controls for the heating equipment, be it boiler furnace, oil or gas burner, or heat pump, to provide seasonal net peak load at optimum efficiency. Equipment sized properly for peak conditions but oversized for the part load conditions which prevail for the vast majority of the winter will use more energy than equipment selected for maximum efficiency at part load conditions of the building.

The placement of the terminal heating device—radiator, convector, air discharge register—determines the length and energy use characteristics of the distribution system; but equally important, it can determine the heat loss characteristics of the building itself. Cold exterior walls or fenestration cause the body to radiate to these surfaces, creating discomfort, and may require a room temperature of 75 F or more for creature comfort, compared to a lower 68 F if the radiant temperature of the surfaces is higher. However, placing a radiator, convector, or air register under the window or along the outside wall perimeter can create greater conductive loss than that surface, since the thin, still air film at the wall boundary is destroyed. A careful trade analysis must be made between loads occurring with different terminal device placements, versus comfort air temperatures required for each discrete condition. It becomes obvious now why a good thermal envelope is important since it also affects the cost and performance of the distribution system.

What about cooling systems?

The same principles hold true for both cooling and heating. However, for cooling, another factor becomes important. There is a saving of 1½ to 2 percent for every degree that chilled water temperature can be raised. For those systems, it is important to vary the chilled water temperature with load so that if 55 F chilled water can handle equal loads, 45 F chilled water should not be supplied. We call this "following the load."

It is also important to reduce building loads with proper solar heat gain control, insulation, roof sprays or ponds, circulation, and other methods, to permit the system to operate at the highest possible discharge air and chilled water temperature. Also, cooling outdoor air with economizer or enthalpy control can reduce the energy requirements for cooling when the outdoor

conditions are more favorable than recirculating indoor warm air.

How can energy conservation be accomplished with the distribution systems—pipes and ducts?

Ducts are more costly and generally have greater heat losses than pipes. If a duct system is used in a large building, the duct length should be minimized and hot or cold water pumped to a conversion device or an air-handling unit near the space that is being served. Also, the air or hot water should be only as warm as required to meet the load. This means varying temperatures. The hotter the fluid in the winter, and the colder in the summer, the more energy losses to the surroundings. Reducing thermal losses is a function of fluid temperature and insulation. In a chilled water system, for example, the colder the water is, the more horsepower it takes to refrigerate it. To do the same job of cooling, and use warmer water, the pump may have to remain on for a longer period of time. The energy used in each part of the system for each period of operation must be evaluated. For heating, don't use 200 F water in a radiator if the space can be heated with 110 F water at that period of time.

With ductwork, the question is: how much horsepower does it take to deliver air from the air-conditioning unit to the terminal device? This is a function of duct size, capacity, and length. High-velocity air systems can be as wasteful as the refrigeration horsepower. The velocities should be kept as low as possible. The lower the velocity, however, the more space ducts take. It is a trade-off. Architects and clients should understand that these analyses of trade-offs must be done early in the design process.

How does energy performance vary with the different duct systems?

Single- or double-duct variable volume systems are generally more efficient than almost any other type of system because air volume is proportional to load, and for a large portion of the time, less air, and a corresponding reduction in air horse-power, is required especially if vaned inlet fans are used, rather than dampers, to control air volume. Double-duct systems are generally wasteful, but double-duct variable volume systems are not so wasteful and improve operational costs.

Induction systems are generally more energy consuming because they are high velocity, and they have a small terminal reheat box in the unit itself. The ducts, however, are smaller and easier to fit into a large building. Terminal reheat systems of all types are energy intensive. Some ex-

cess energy is used to cool all the air whether the zone requires it or not. Additional energy is used to reheat the air to that zone which does not require cool air.

What are the advantages and disadvantages of using a central system versus small individual units?

Central air-conditioning systems can consist of either: (1) centrifugal screw machines, (2) absorption chillers, chilled-water piping, and remote airhandling units, (3) large central air handling units with extensive duct distribution systems, (4) reciprocating compressors and large air-handling units. The energy use characteristics vary considerably with the type of control system and the type of distribution system. Often the air-handling units can consume a large portion of the total energy required for compressor, fans, and cooling towers. Window units, through-the-wall incremental units, or small package air-conditioning units have a lower COP (coefficient of performance per unit of energy consumed), lower efficiency than the better central units, but also require considerably less horsepower for air distribution. The energy required for each system and subsystem must be fully evaluated. Individual units can be readily turned off when not in use. When they are not, the energy savings proclaimed for individual units may not be realized.

Large systems with proper controls can be operated in close accordance with load, too, and can be just as efficient in that regard as the decentralized smaller systems. The larger central station equipment is generally of higher quality and has a higher COP than the small, mass-produced-for-a-market decentralized units. Larger equipment also has a longer useful life, better filtration capabilities, and better humidity control than window units or their equivalent.

Efficiency may also be a function of the climate. Sometimes, for example, an aircooled condenser can be more efficient than a water-cooled condenser and cooling tower. In a climate where the dry-bulb temperatures are always low and the relative humidity is high, an air-cooled condenser rather than a cooling tower will be more efficient. However, if the relative humidity is low and the temperature is high, a cooling tower and water-cooled condenser are more efficient. The climatic conditions which prevail for the longest period of time determine the proper choice of condenser. Note that time, duration, as well as (or rather than) peak conditions are the important factors in the energy usage and conservation for most systems.

One heat-pump manufacturer recently told me that his sales of air-to-air heat

Active general conservation

pumps have increased fifteenfold since 1973. A heat pump starts to lose its effectiveness below freezing temperatures. When does a heat pump prove to be an economical solution?

Air-to-air heat-pump systems are most efficient in moderate climates, design temperatures above 35 F, since a selection of heat-pump size can be made so that the COP is relatively high and no auxiliary energy is required. In colder climates, oversizing the heat pump will produce a higher coefficient of performance. Exhaust air from buildings or processes can be used as a heat source to increase heat pump efficiencies. Multispeed, multicapacity heat pumps are more efficient than similar sized single capacity systems. Water source heat pumps, or dumped heat pumps using water or air, can be very efficient as can air or water source heat pumps used with solar collectors or located in a solar-heated attic. Deep wells or ground water used to provide heat for water source heat pumps are generally more efficient than air-to-air heat pumps because of the higher heat source temperature.

Do you use more natural ventilation now as opposed to completely closed systems five years ago?

There are limitations to what can be done with natural ventilation. The external conditions are not always so sweet; there is pollution, noise, and dirt. It is more common today, however, than it has been for a long time. We are designing buildings to enhance natural ventilation with the building structure and opening. Wind and local air movement affect window design and placement, induced air towers, and stack action.

Is there a greater concern today for air cleanliness and air purity?

The ambient outdoor quality is degenerating in spite of more stringent air quality requirements. Many urban, and even rural, areas are highly polluted for many long periods of the year. We are increasingly concerned with air quality in buildings, and air quality in hospitals and laboratories is of special concern. We find that we can maintain proper air quality control better with recirculating systems with proper filtration than by introducing outside air of questionable quality into the spaces. Control of smoking in public buildings can produce significant energy savings by reducing outdoor air requirements or fan horsepower for recirculated filtered

air systems. In many buildings we are using absorption and charcoal filtration systems, with recirculation to maintain air quality and to save energy by reducing the amount of outdoor air that would be required for dilution.

How much can be done with air motion and relative humidity?

That is a good question. For cooling, a great deal can be done with air motion to provide comfort without excessive energy consumption. Localized fans can move the air within a space, with very little horse-power, to evaporate body moisture and create a cooling effect on the skin. Airconditioning costs can be cut with more air and better air motion distribution. Comfort is a function of air temperature, air movement, relative humidity, and mean radiant surface temperature.

Energy can also be saved by lowering the humidity in the winter. If it goes too low, it is uncomfortable and the temperature must be raised to compensate. Twenty Rh in the winter appears to be as effective as 40 Rh and a lot less energy is required to maintain it.

Water conservation has become a major effort by many plumbing fixture manufacturers. In large buildings, how much of an effect does the hot water load have?

In many office buildings, the amount of energy used to heat hot water, approximately one to two gallons per day per occupant, accounts for a relatively small amount of energy used by the building. However, we can reduce water temperature from the usual 140 F to 100 F, and the quantity of water to 1/4- to 1/2-gallon per minute per faucet. The capital cost required to reduce energy consumption is very small, and should not be neglected. In laboratories, hospitals, housing, and schools, the energy required to heat hot water can be 20 to 50 percent of the energy requirements for the entire building, especially where minimum space heating is required as in the South.

Insulating the hot-water piping and storage tank, reducing water flow with special fixtures or orifices in the piping, reducing the hot water temperature for general building use (and only boosting it locally where required for special use like dishwashing) can result in significant savings. Separate water heaters for summer use. rather than using the oversized building space heating boiler for heating domestic hot water, and solar water heaters, should also be considered for energy conservation. Although they affect building design very little, if the architect is the overall manager of the building project design, he must be cognizant of these opportunities.

Has the energy crunch meant a more frequent reuse of drain water—gray water?

There is always a great fear and danger of bringing water back into the building once it has been used. We know a great deal about bacteria, but we are still ignorant of the effects of many viruses. Wherever there is reuse of water, there is a possibility of a cross connection between the "fresh" water and that which has become contaminated. We generally avoid water reuse, although it sometimes can mean a tremendous saving. The energy required to treat potable waters, build sanitary piping systems, and treat sewage is tremendous. Reduced water use saves energy in all these sectors.

In a residence, I would be very leery about bringing water back into the building, no matter where it comes from. Bath water might eventually be commonly used in flush toilets as safe systems are devised. In industrial and larger commercial buildings, gray water can be used for flushing and for irrigation, but I would recommend two separate piping systems: one for gray water and one for potable water. Water conservation is a major national need, approaching the same level of concern as the energy crisis.

There will be an article following this one which will concern itself with lighting. It would be appropriate, however, if you would outline some of the major areas of energy conservation in lighting design.

Let's start with the energy management program. It includes a description of the function-dependent quantity and quality of illumination required for each room and each distinct space within a room. The program deals with the visual tasks to be performed, the duration and critical nature of each task, the cycles or random operation and occupancy within the space, and the possible changes that can occur within the spaces. In other words, it states the requirements for an adaptable lighting system, not simply a flexible one.

The opportunities for providing natural illumination must be carefully considered. The window area and placement, top lighting options, wall, ceiling, and floor interreflectances can all play a role. There is a trade-off between the energy saved by daylighting for illumination and the increased energy burden for heating and cooling through the windows or skylights. Since natural lighting produces only a fourth as much heat as fluorescent lighting, the air-conditioning load is reduced, but heating requirements are increased. The options must be evaluated, taking into consideration such design considerations as double glazing and thermal barriers at night to reduce nocturnal heat loss through

windows but allowing natural illumination during the daytime.

High-intensity-discharge lamps and other lamps with greater efficacy than incandescent or fluorescent lighting can reduce the energy required for artificial illumination two- to fourfold. Multicapacity ballasts, switches on timers, multiswitches and photocells can all be used to control artificial lighting so that energy is used only when and to the extent that auxiliary lighting is required.

Another energy topic concerning lighting is heat recovery. I feel, generally, that if it is going to be efficient to recover heat from lights, then there is probably too much light in the first place. If, however, the air can be drawn out through the lights at no penalty, then why not do it? The amount of air supplied to a space is directly proportionate to the sensible heat gain in the space. If some of the heat can be removed from the source, the conditioned air quantity can be reduced.

People tend to underestimate the contribution of operational aspects of energy design. As the standards for energy performance tighten aren't we likely to see an increase in use of central control systems?

Something or someone has to optimize the operation of building equipment. In large buildings, even those as small as 30,000 sq ft in area, a central control system can be very cost effective. A central control system with microprocessors and a minicomputer senses temperatures, resets controls, and optimizes energy consumption. The system can tell us precisely when to raise the chilled water temperature and add more water or lower it a bit and reduce the water flow, or can be put on line and make the adjustments automatically. With a manual system, valuable time and energy can be lost just making the decisions to make the adjustments. Control systems do not shrink from complexity the way people do.

Of course computers will never replace the service and maintenance responsibilities of a building. If a machine breaks down someone must be there to fix it. How does good maintenance affect energy use?

Control systems can minimize maintenance requirements and also indicate when maintenance is required. Maintenance programs are very important for effective energy consumption. More thought—architecturally—should be given to the cleaning and ease of replacement of lights and filters, for example.

Lighting performance falls off rapidly as lamps become dirty, and more lamps are required with more energy used if the lamps are dirty. Clogged filters reduce air

flow, requiring longer operation of the heating or evolving equipment. Dirty and scaled boiler tubes, condenser tubes, and heat exchangers require more energy. Good maintenance can reduce energy consumption 10 to 30 percent in most buildings. Central control systems to indicate equipment condition, coupled with a competent and attentive maintenance staff, are essential to optimize energy conservation and machine life.

Let's get down to some general topics that directly relate to the architectural form. What formal ramifications will result from increasing consciousness of energy in mechanical design?

I think for example we should be looking more to exposed ducts and piping rather than hiding them as we have done in the past. These elements should be worked into the design. Consider an exposed duct compared to a duct enclosed within a dropped ceiling. Which is going to cause more energy to be used? In the cooling season the exposed duct is the more efficient. The space within the dropped ceiling heats up in the summer and can heat the cool air flowing through the ducts, requiring more air to assure proper delivery temperature. The duct running through the conditioned space is running through the cooled space. In the winter, the temperature gradient between the conditioned space and the dropped ceiling space gives little advantage to either solution.

Building configuration and a plan that allows greater heating or cooling air distribution reduces the losses through the mechanical distribution system and can reduce equipment operation time and wide temperature swings. The location of equipment rooms near the loads they serve also reduces energy for distribution systems.

Won't the occurrence of these pipes and ducts within the space also mean that the effective floor to ceiling height can be reduced?

Yes. A smaller volume of space to heat or cool reduces energy consumption. However, cooling requirements can be reduced in tall spaces by distributing cool air at an intermediate level and allowing the warm air to accumulate at the high points without disturbing it.

If we follow your earlier suggestions, we will also be using larger ducts.

Yes, and the proper allocation of space must be made. The larger ducts require less air horsepower for fans. The architect will need to familiarize himself with the rules of efficient duct proportioning and

geometry and think about the optimum location of equipment.

One subject with which I would like to end this article is the art of building. Architects fear that with energy design, they have lost the battle between science and the art of building. From what you have said the opposite is true. It is just as much an art as a science to assemble a building recognizing the thermodynamic principles. Now the question is, what every artist would ask, how can he get a feel for the medium. How can he achieve the kind of gut response that allows him not only to create art but good art?

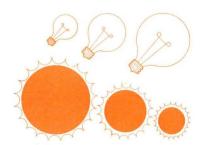
He must understand the principles and understand their importance in the hierarchy of things. He can't just read about it. I think he really has to physically understand the dynamics of the structure of the environment and the effects of his decisions. He will begin to see that these are really great influences and, all of a sudden, he will begin to love these things. Then he will want to express them, and they will begin to shape the building form.

Energy and design are not incompatible, they are one and the same. These principles of climate and energy use are not incompatible with the design, they are the design! The challenge becomes creating the environment, the physical environment and the functioning space, in an energy-conscious setting. Many architects do not want to face the challenge. Some say they have one thing to think about and that is visual beauty. That, to me, is not architecture. There is a difference between architecture and the other visual arts. Architecture must be a marriage of science and art.

The same is true for the engineer. He must get involved with buildings as total systems. Almost anybody can be taught how to do a heat loss calculation, and that is not engineering. Engineering, to me, is marrying the energy systems with the structure that houses them. The ultimate is to create buildings, cities, regions, that enhance our quality of life.

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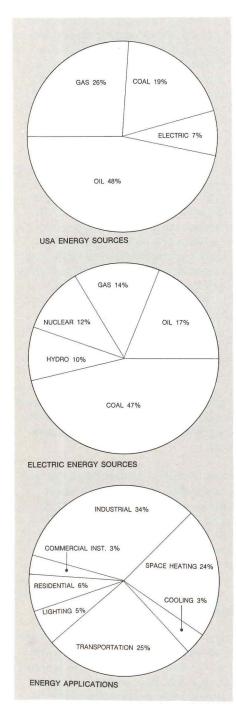
Light motives



The new energy consciousness has led to a thorough reevaluation, by both manufacturers and interior designers, of how artificial lighting can be used wisely, while other researchers have explored the potential of daylighting as an alternative interior light source.

It has been estimated that, of our national energy resources, some 5 percent is used for lighting—a relatively small part of our total energy consumption. Where does the electrical energy for that lighting come from? According to the U.S. Department of Energy (Monthly Energy Review, March 1978), the largest part (47 percent) is generated from coal, followed in order of magnitude by oil (17 percent), natural gas (14 percent), nuclear energy (12 percent) and hydro energy (10 percent). Compared to the fact that 48 percent of all energy in the United Sates is fueled by oil, the current status of lighting energy consumption seems much more favorable than that of the energy situation as a whole: lighting is much less dependent on oil than heavy industry and transportation (the two biggest consumers of energy, at 41 percent and 25 percent respectively). Artificial lighting makes major use of an energy resource coal—that has been estimated by some to be capable of lasting at present levels of consumption for several more centuries at least.

Why then all the increased interest of late in the improved efficiency of lighting?—the topic that has become a major source of concern to manufacturers and lighting designers, to interior environmental researchers and governmental regulatory agencies in the past few years. It is true that the primary energy source for most lighting in America is more secure and more abundant than that which has been responsible for our awareness of energy as a finite (and costly) resource—



oil. But it is also true that the movement for better, more efficient, and healthier interior lighting design would have probably happened without the larger events that have precipitated the rise of energy consciousness in all areas of our national life.

The motivation to make better use of artificial lighting has a great deal to do with money, for although the long-term picture for electrical energy production seems relatively stable, the costs of producing that electricity have mounted sharply and rapidly. Furthermore, many electrical utility companies in the United States are not particularly interested in increasing their rates of production (the significant investment of capital needed for the expansion of generating plants has likewise been subject to inflationary trends). And some electrical energy producers are in effect pursuing policies of encouraging reduced consumption while raising rates: the new business trend toward less for more.

But there is another, and less commercially inspired, component in this overall movement, one which recognizes the end-user as the real beneficiary and central focus of these efforts. For while all the latest cost-saving innovations have been given the lion's share of attention in the development of better lighting for the future. there has been a great deal of lighting research that has centered around the realization that none of these innovations in interior lighting will have any lasting value at all if they do not benefit people. That benefit has been interpreted variously as increased satisfaction with one's environment (especially in the office), greater personal comfort, increased productivity, or any number of other, more specialized factors. How those needs are being interpreted and met in various sectors of the lighting industry can give an illuminating overview of these important new movements in interior lighting design today.

The major innovation in commercial as-

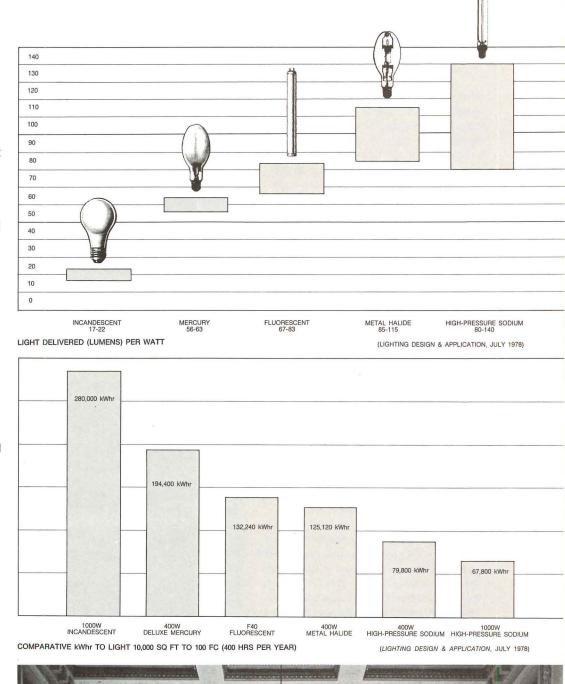
pects of interior lighting over the past decade has been the development of more efficient light sources. Almost exactly 100 years ago-on October 21, 1879-Thomas Edison perfected his invention of the first incandescent electrical lamp. That first lamp gave off approximately 1.5 lumens per watt, while today's incandescent lamp of similar size can give off some 20 lumens per watt: a capsule illustration of the general trend over the past century (though most dramatically since 1920) of steadily increasing efficiency from artificial light. That increased efficiency within one kind of lighting system does not even hint at the even more dramatic levels of efficiency achieved in new kinds of lamps developed in the wake of Edison's epochal discovery. For example, here are some comparisons of how much light is delivered—in lumens per watt—by four other kinds of lamps introduced subsequent to the incandescent lamp; mercury lamp (avg. 60 lpw); fluorescent (avg. 75 lpw); metal halide (avg. 100 lpw) and high-pressure sodium (avg. 110 lpw).

Of equal importance in judging energy efficiency is the amount of energy required to operate any of the lamps listed above, and here the figures are no less dramatic. For example, it has been estimated that a high-pressure sodium lamp can light an area with about only 25 percent of the energy required to light that same area with incandescent light. Fluorescent lighting falls just about halfway between those two extremes: it is about half as energyefficient as high-pressure sodium illumination, and about twice as efficient as incandescent. Needless to say, there has been a dramatic turn to high-pressure sodium lamps as a quite direct result of these greatly increased energy/efficiency ratios. Incandescent and mercury lighting (the two lowest sources on the efficiency scale) are gradually being phased out in favor of metal halide and high-pressure sodium lighting for most commercial settings, whereas fluorescent lighting is receiving increased attention as a replacement for incandescent lighting in residential interiors (according to HUD, lighting accounts for 2 percent of domestic energy use).

Going back to natural

But despite the considerable efforts of the major electrical lighting manufacturers to provide increasingly efficient and costeffective lighting, there has nevertheless

High-pressure sodium lighting is being used with increasing frequency in interiors. One of the first such installations was the Dinand Library at Holy Cross College, Worcester, Ma., which was converted from incandescent to recessed 400-watt Lucalox high-pressure sodium lamps by General Electric in 1968 (right).





Energy-conservative lighting

been a growing trend in this country toward reducing use of artificial light, or even dispensing with it completely during the day. This daylighting movement has as its basic premise the belief that the use of passive energy sources where at all possible is preferable to the use of any artificial energy system, no matter how efficiently a technological source might make use of fuel, no matter how plentiful that fuel might be. That attitude is one of the more striking outgrowths of the energyconservation consciousness as it has evolved lately: instituting energy savings not out of external duress, but proceeding instead from a philosophical belief in the inherent benefits of anything natural over anything man-made.

Is there some intuitive wisdom at work here? Perhaps. The effect that various kinds of artificial light might have on human health has come under increasing scrutiny lately. The subject is now being probed by the Laboratory of Environmental Biophysics (newly established by the National Institutes of Health in North Carolina), as well as by researchers for two new investigative groups: the Center for Light Research in Fort Lauderdale, and the American Society of Photobiology at Stanford University. Currently, the two latter research bodies are looking into the possible injurious effects of fluorescent lighting on animals, an as yet unproven link for which there is already, however, a certain amount of preliminary evidence. More substantive findings are said to be imminent. But the most comprehensive research on daylighting has been going on at the National Bureau of Standards' Center for Building Technology in Gaithersburg, Md. There, the Environmental Design Research Division has been responsible for a great deal of the pioneering inquiries into the subject, providing fundamental research data that has served as the basis of research carried out elsewhere on daylighting.

At the heart of the matter is the fact that Americans as a whole are spending less and less time exposed to natural light; most of us spend most of our days in offices or factories under some sort of artificial light, without the full spectral range of natural light. The fact that most interior lighting in this country is fluorescent is compounded by the fact that fluorescent light has a much more distorted spectrum than incandescent light. So while many lighting designers and manufacturers are preoccupied with such concerns as energy efficiency, color rendition, or visual comfort, it might well be that the most important factor of all—light's contribution to overall human health—has been largely

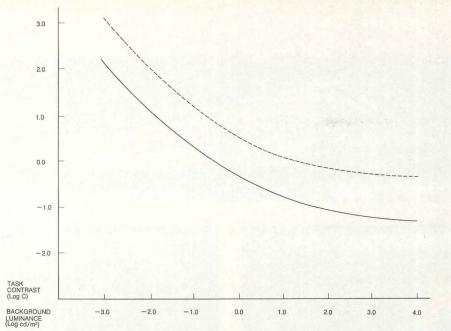


Ceiling configurations reduce ballast noise in HID installations by GE (above) and Lightolier (below).

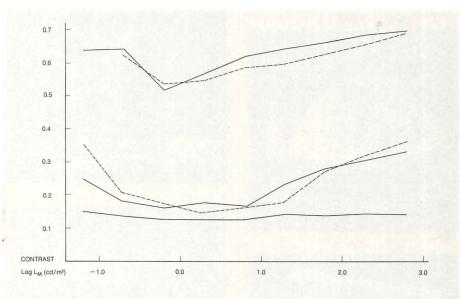


HID lamps (Lucalox by GE, below) have gained even wider acceptance in industrial settings





The visual performance reference base used by the Illuminating Engineering Society for recommending levels of illumination (solid curve) is Visibility Reference Function, dashed curve is Visual Performance Criterion Function.)



Equal-clarity contours as a function of mean spatial luminance for a sine-wave grating of frequency Cpd. (The solid and dashed curves represent the results for two different observers.)

The two graphs above illustrate one of the more significant pieces of research on the energyefficiency of interior lighting. Conducted by Gary T. Yonemura and Yoshimi Kohayakawa, guest workers at the Center for Building Technology at the National Bureau of Standards, the research was summarized in a report entitled A New Look at the Research Basis for Lighting Level Recommendations (NBS Building Science Series 82, U.S. Government Printing Office, 1976.) The report's findings created an immediate sensation within the lighting industry, for both manufacturers and designers saw some of their basic assumptions about lighting levels severely called into question. The prevailing opinion before this report is summarized in the graph (top) that shows a direct relationship between brightness levels and visual performance: the more light, the better visibility. However, in what might be termed a classic piece of NBS research, Yonemura and Kohayakawa undertook a reexamination of those recommended lighting levels and found that such was not the case at all. The graph of their results (bottom) indicates that after a certain point, just the opposite of the IES standards is true: not only does higher lighting level not mean greater visibility, but it can actually mean less visibility. Thus, the position of many designers and conservation-minded users is given solid scientific support. To quote from the NBS report: "If the aim of interior lighting is to ensure adequate illumination levels for the most difficult task encountered, then the present Visibility Reference Function may be the appropriate standard. In a typical visual environment the most difficult task (although encountered infrequently) may be near threshold levels. The results of the study indicate that, in order to accommodate for this infrequent occurrence, a price must be paid. The higher luminance levels recommended to satisfy the requirements for seldom-occurring low contrast tasks may bring the luminance level beyond the optimum luminance level for tasks with good contrast. The above is an instance of 'less light, better sight' and seriously questions the indiscriminate application, as a working rule, of the popular notion 'more light, better sight.' "

and recklessly overlooked.

Thus the trend toward daylighting might well be a very significant one in the future. As is the case with so many energy factors, daylighting would prove to be most effective in buildings specifically designed with that capability in mind, but considerably less desirable in buildings where the initial design (or difficulty involved in retrofit) reduces the overall benefits. For example, the new California State Office Building competition (P/A, Feb. 1978, pp. 70-73; P/A, Jan. 1979, p. 80) had daylighting as one of the design criteria for the building, and the winning entry was distinguished by a number of features to allow that potential. Massing of the structure was broken down to provide more window exposure than that of the average high-rise office box, an atrium and skylights further admitted natural light into the interiors, and both interior and exterior reflection levels were considered so as to require considerably less artificial illumination than most buildings today. Several research groups around the country have been actively involved in codifying the growing mass of data on daylighting.

Among them are the faculty and research assistants at the Institute for Environmental Studies at the University of Washington in Seattle, who have developed a new graphic-design aid for the prediction of natural and artificial light levels in interiors. Prof. Harvey J. Bryan of the Department of Architecture at Berkeley has done a state-of-the-art compilation of daylighting research to date, and numerous individual practicing architects (especially on the West Coast, where the daylighting movement seems to be especially vigorous) have been involved in furthering this alternative interior lighting movement.

Throwing less light on the subject

But it would be a serious miscalculation to think that daylighting has any more than limited potential to solve our interior lighting needs. The most obvious drawback is its potential to function effectively only during daylight hours, and then adequately only on days with sufficient levels of daylight. Also, the design of a great majority of existing buildings (buildings that will have to be used regardless of their current energy efficiency) is just not suitable to daylighting at any reasonable level of effectiveness. For the most part, our attentions are going to have to be given to the development of more intelligently worked-out interior lighting schemes in which design and technology work hand in hand to provide a maximally effective and efficient working and living environment.

One of the more encouraging aspects in interior lighting, therefore, has been the increased awareness that artificial illumination is, above all, for the benefit of people,

Energy-conservative lighting

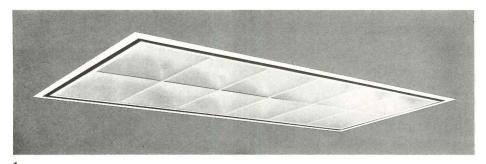
and not spaces; that the old criterion of watts per sq ft ("building watts") has much less a place in good lighting design than does the concept of watts per person ("people watts"). For example, one of the most highly publicized aspects of interior lighting design in the 1970s has been that of task/ambient lighting. Yet now, many lighting designers and manufacturers, in their increased respect for end-user needs, prefer to talk and think about ambient/task lighting, the difference being in the realization that ambient lighting is responsible for some two-thirds of the illumination in most well-designed interior lighting schemes.

More and more now, lighting designers are using ambient light to carry the load of office illumination, with a noticeable trend in energy-efficient designs toward the use of more than 50 percent localized, nonuniform ambient light, coming from high-intensity-discharge (HID) sources, supplemented with variable task lighting. The increased emphasis on localized ambient lighting works in nicely with the increasing conversion in offices and commercial installations to various kinds of HID lamps, offering the possibility of using fewer luminaires per square footage to be lit. Therefore, the combination of fewer fixtures providing the same amount of illumination futher enhances the flexibility needed in making interiors more energy effective.

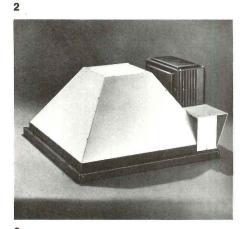
Spreading it around

Of equal significance to the development of new and dramatically more efficient light sources is the concurrent development of better optics potential in light fixtures to better diffuse light from the new highefficiency lamps. The mere replacement of less efficient lamps with more efficient ones will of course result in more energyconservative illumination, but the examina-

Some of the energy-efficient lamps and luminaires currently available: 1 Parabolume high-efficiency luminaires by Columbia Lighting. 2 New 50-watt Lucalox HPS lamp, by GE—the lowest wattage HPS lamp commercially available. 3 Halo Lighting 2x2 recessed square HID fixture, by McGraw-Edison. 4 GTE's 400-watt Super Metalarc lamp by Sylvania, providing up to 100 percent more lumens of light than a 400-watt mercury lamp. 5 Maxi-Miser F40 fluorescent lamp/ballast system by GE. 6 LESS automatic lighting control system by Novitas, Inc. turns incandescent or fluorescent lights on and off as people enter and leave any size room or area. 7 Sylvania 880-watt Unalux HPS lamp by GTE. 8 Round lens unit from Halo indoor HID line by McGraw-Edison.

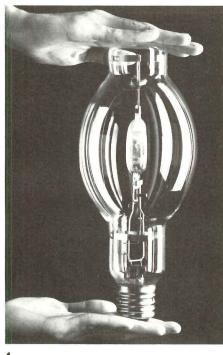


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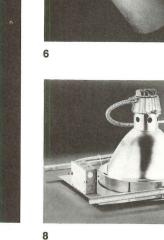












tion of the luminaires themselves and the role they play in diffusion should be part of the process as well. Most responsible lighting designers would agree that there are no hard and fast rules that are uniformly applicable to energy-efficient interiorlighting design. Every interior scheme is a law unto itself and requires individual evaluation and attention. Yet there are a number of basic criteria that must be thought about in the planning of energy-efficient lighting, and they are common to all interiors, regardless of the specific settings.

As with many aspects of architecture and interior design, the federal and state governments are promulgating more and more guidelines for levels of interior illumination, from the standpoint of energy consumption, and user requirements as well. Unfortunately, it is too often the case that such regulations govern the quantity of light, but not necessarily (and more subjectively) the quality of light. The most common factors affecting light quality are glare (now generally determined by a factor known as Visual Comfort Probability, or VCP) and veiling reflections (which minimize contrast on the surface of objects illuminated). Thus, a more important criterion than mere footcandles is that of Equivalent Sphere Illumination, or ESI, which is used to gauge actual visual comfort. The importance of ESI level is that it supports the basic tenet of energy-conscious lighting practice: not only is it smarter to use less energy where at all possible, it can also give you better lighting as well.

Thus the notion that more does not necessarily mean better is finally beginning to take hold in an important segment of the interior design world. This is equally true in office, commercial, and residential settings. For example, in retail settings, it has been discovered that nonuniform ambient lighting (concentrating light sources over important display areas, and eliminating the long-dominant use of uniform ambient light) can act as a subtle but effective spur to sales, giving products on display an alluring emphasis in a crowded visual environment that all too often equalizes objects to a detrimental degree.

In residential settings, the increasing use of dimmers allows for adjustment of light levels to suit varying illumination requirements, a factor achieving much greater popularity as the flexibility of our living spaces increases with every new year. Thus, the level of light needed for a child to do his homework at the dining room table is by no means the same needed (or desired) during a dinner party at the same place. To a remarkable extent, people in residential settings can provide a lighting level commensurate with the activity involved, tending to be much more accurately attuned to the real illumination



Although task lighting remains an important part of interior lighting (above, by Lightolier), many energy-conscious designers now think in terms of ambient/task rather than task/ambient.

needs than in an office setting for example, where preoccupation with work tends to make that awareness less apparent on a conscious level.

Apples and oranges

The comparison of relative energy effectiveness and user suitability is one of the hardest aspects of interior lighting design to determine properly, primarily because so many variables are involved among differing settings, tasks, and conservation requirements. However, several points remain essential for the further development of effective energy-efficient interior lighting. On the part of lighting manufacturers, there is the need to continue to develop products that can achieve predictable results. Now with the increased presence of the architect in interior design (another factor that will have a great impact on energy-conserving lighting), the need for maintenance and extension of industry-wide standards is imperative.

On the part of architects and interior designers, it is no less essential to learn (if they do not already know) how to evaluate lighting systems and their components in such a way as to determine for themselves their true energy effectiveness. Although such a trend will never eliminate the need for lighting specialists and consultants, it will at least make the services of those professionals more relevant to the coordination of all the design disciplines—a unity that is by definition so very essential in good interior design practice. On the governmental level, the legislation on interior lighting that is being enacted with increasing frequency across the country must reflect the findings of the lighting, interior design, and architectural professions working together to create better interior environments, and not just those of regulatory agencies that deal with blanket rules rather than flexible, realistic applications.

Interior lighting in the past 10 years has

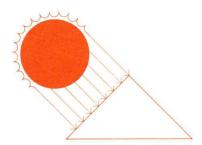
probably changed more dramatically than it has over any other decade since the development of that first electric lamp a century ago. The coming changes—new findings about the effect that light has on human health, the deepening energy crisis, the proliferation of new lighting products and design options, the rethinking of the way we use light and the kinds of light we use, the increased importance of the lighting professional as part of the architectural and interior design teammake the 1980s appear no less fraught with change than the 1970s. The continuing education of the architect and interior designer will become perhaps the central factor in achieving better interior lighting design, for even those who have had sound educational backgrounds in lighting design will need to be kept abreast of innovations in interior lighting the nature of which we might not even foresee as yet. Given a century of practice in the application of artificial light, we can only hope that the beginning of the second century will see at last the final realization of the full potential for perhaps the most miraculous human invention of them all. [Martin Filler]

Acknowledgements

We wish to thank the following individuals, agencies, and manufacturers for their help in preparing this article: Jose Raul Bernardo, Joyner/Bernardo Associates; Jeremiah Blitzer, Lightolier; Will Ca.vill, General Electric, Nela Park; Center for Building Technology, National Bureau of Standards: Dr. Edward A. Arens, Mr. Noel J. Raufaste, Jr., Dr. Arthur I. Rubin, Dr. Francis T. Ventre (Gary T. Yonemura and Yoshimi Kohayakawa, guest workers); Alan J. Ruud, PE, SPI Lighting, Specified Products, Inc.—Stephen Johnstone (Hoffman, York, Baker & Johnson). For energy-conservative lighting product and literature information, see page 182.

Solar: trial and error

Sandra Oddo



Since many of the results of active solar approaches must be measured on built houses, these examples are a preview.

For awhile, in the early euphoric days of solar awareness (1973 & 1974, that is, after that oil embargo bludgeoned us awake), it looked as if active solar systems would have it all their own way. Stick the thing on the roof, unplug the old furnace, and you're all set. Experimentation and experience since then have proved that view simplistic, to say the least. For one thing, in those days, some basic data were misleading, or missing entirely. Insolation data, information on the actual solar energy arriving in various parts of the country, were patchy. The Weather Service monitors that collect the data—along with information on winds, rains, temperatures, and weather in general—were originally in position to favor the best collection of other kinds of data, and that position has not been substantially changed, or even well serviced, since the 1930s. Information on the performance of materials under actual conditions of use was nonexistent. Solar collectors had performed under laboratory conditions for a long time, with data collected in a more or less organized manner since 1955 under the auspices of the International Solar Energy Society. A lot was known about materials; little was known about the effects of combinations of those materials and about the niceties of collector design and manufacturing

The most imponderable variable, as it turned out, has been the transition between the manufacturer and the roof—the installer. Standards of roofing and plumbing that suffice for roofs and simple running water do not suffice for the addition of a solar collector and its associated pipes of fluids. The call-back rate for the hundred systems installed in an early water-heating

demonstration program by the New England Electric System was well over 50 percent. A real learning experience, according to spokespeople for the system, which has plugged doggedly ahead to apply the lessons learned.

The most important of these lessons seems to be that a solar collector of any type is not simply a replacement for some other form of heat supply. This relatively innocuous realization has implications that affect all of architecture, if we assume solar will play a major role. Architects have had a lot of fun, even moments of high art, using the freedom from structural constraints that the materials, the machines, and the cheap energy of the last few decades have allowed. That era is ending. The era of architectural challenge now opening up seems likely to remodel our concept of the function of architecture and to reshape the look of buildings from now on.

A little over a year ago, President Carter set a 1985 goal of 2.5 million houses using solar energy. That goal looked conservative at the time. According to David Morris, codirector of the Institute for Local Self-Reliance in Washington, DC, if it were assumed that space heat for a 1200-sq-ft house required a 600-sq-ft collector, and that a family of four needed 60 sq ft of collector for water heating purposes; and that production would increase by 30 percent each year, a city of 100,000 people should install only 13 solar heating systems and 52 hot-water heaters in 1979.

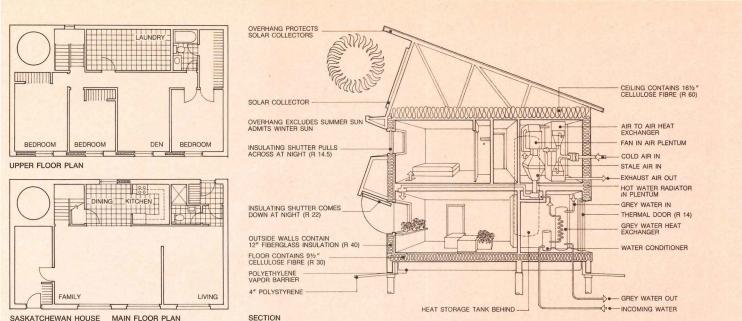
Harvard/MIT's Joint Center for Urban Studies estimates that between 20 and 22 million new residential units will be needed by 1985. Many solar people (among them, Jerry Yudelson, director of the State of California's SolarCal office, responsible for part of the certification for California's 55 percent solar tax credit) believe that perhaps as many as 50 percent of those houses will be oriented toward the sun.

Solar systems are not complicated, but

they are unforgiving. A collector must face generally south, because that's where the sun is. A few degrees of tilt, or a few inches or feet of change in the size, shape and placement of the storage bin makes a difference. Fossil fuel, basically, is solar energy concentrated by millions of years worth of geological and chemical processes into neat, portable packages. Raw solar energy is sloppier. It falls everywhere, at a concentration of about 300 Btu per sq ft per hour—about the same amount of heat a human body gives off. If you need a certain number of Btu's, you have to have a certain number of sq ft of collector, and beyond that you have to guard all the allied systems of heat transportation and storage to keep the slippery stuff from getting away. This means that the architect must work with stringent physical limitations, because his work is crucial to the physical functioning of the house as a heat-collection machine. It's a whole new era in house design.

The heralds of that era of architectural challenge are unprepossessing; a spate of demonstration projects sponsored by government, private industry and business, utilities, and a larger rash of individual projects initiated and carried out by individuals. Not many of the buildings are gorgeous to look at. Not many are even very efficient at saving energy or using solar heat. Things looked more promising to solar people at first than they have turned out to be—after an average 60 percent increase in square footage of collectors manufactured every six months for the last four years, production has slowed; buyers stalled waiting for the passage of tax breaks; problems were persistent, and drew adverse publicity. While tax incentives are with us (see It's the law, p. 180), the stimulation of the solar equipment industry is only now beginning to be felt. But still, it's the beginning of the future.

Three of the many government/industry



demonstration projects are particularly interesting, because the results and conclusions to be drawn from them may point one way to the shape of that future—and those conclusions are somewhat equivocal.

The Saskatchewan Conservation House

The Saskatchewan Conservation House project in Regina, Canada—where the sun does shine in winter, but not often and not long, and where January temperatures average -20 C (-4 F)—was an effort by the Saskatchewan Dept. of Mineral Resources, assisted by the Canadian Research Council, the Universities of Saskatchewan and Regina, the Saskatchewan Power Corporation, and Housing and Urban Development Association of Canada, to demonstrate the effectiveness of conservation efforts aimed at reducing energy consumption in a single-family house by 85 percent. The actual building needs less than 5 percent as much heat as a comparable conventional house.

The situation

Annual degree-day average in Regina (in degrees Fahrenheit) is about 10,600. For comparison, the three coldest weather stations in the U.S. measure averages between 8000 and 10,000 degree days.

Typical houses located there lose heated inside air at a rate of one volume change per hour. One of the greatest energy-saving items for the Conservation House, therefore, has been a fanatical attention to infiltration. The vapor barrier is 6-mil polyethylene rather than the standard 2-mil, extended through floor and ceiling, sealed at the seams, and caulked with an acoustic material that is supposed to stay flexible

Application methods for the vapor barrier were changed: workers' boots and accidental nails were not permitted to do their Swiss-cheesery on it before installation. All electrical features were set into in-

sulating plastic pans developed by an Edmonton (Alberta) firm. The house thereby became a balloon, more or less, with a 17–25 percent air change per hour, using a powered ventilation system—adequate to control water vapor, says Dr. Bezant.

The soil in Regina has an expansive clay base subject to fairly radical thermal movement. Basements crack. The Conservation House, therefore, has no basement. It sits squarely on the ground, its 2" x 10" floor joists over a tiny sealed crawl space provided with a vapor barrier, and power vented in summer. Grade beams are insulated with polystyrene that extends 6 in. under the soil to form an apron 4 ft wide around the house.

The house

The features that make the Saskatchewan House energy conservative are not so much matters of cost as they are changes of habit, according to Floyd Wist, acting director of the Office of Energy Conservation (in charge of the project), part of the Saskatchewan Dept. of Mineral Resources. The concept "house" has been rethought in terms of Saskatchewan's climate. The walls, for instance, are 1 ft thick and double, built using a system developed by the Saskatchewan Research Council. The outer wall on both stories is standard 2" x 4" frame construction, but each floor has an inner wall, of 2" x 6" on the first floor and 2" x 4" on the second. Three layers of fiberglass batts (R-40) laid vertically, then horizontally, then vertically fill the cavities. Framing is designed to eliminate thermal paths to the outside. Fiberglass was used to avoid insulation settling in the thick walls, but the floor (R-30 plus an arbitrary assignment of R-10 for the insulating value of the earth) and the ceiling (R-60) are insulated with cellular fiber, recycled paper processed by a local manufacturer. Almost all the window area is on the south

side—rather, 21 degrees west of south, because the house is oriented to test less than ideal siting. The picture windows downstairs are double glass, insulated at night by an exterior shutter (6-in. polystyrene in an aluminum shell, R-22), hinged to swing up against the underside of the overhang during the day. The seal around the shutters is not yet as tight as was hoped, says Wist. Upstairs, the bedroom windows are double-glazed inside and single-glazed outside. The nighttime insulating shutter (polystyrene, R-14.5) slides from a pocket in the wall into the space between the two. One of the two small windows on the north has a similar shutter; the other has a friction-fitted batt of fiberglass for nighttime insulation as a demonstration.

The house is sided with cedar shingles, dark to help absorb heat; deciduous trees are planted on the south for summer shading; conifers on the north help to break winter winds. Overhangs shade both collectors and south windows in the summer.

Some details

Bathroom taps, showers, and toilets are designed to conserve water. Hot wastewater from sinks and tub is collected into a holding tank in which a domestic water preheater is immersed. "In retrospect, I wouldn't recommend it," says Wist. Temperatures are highly variable, and the possibility of cross-contamination has to be carefully checked. The system needs special exemption from building codes. "There are probably better ways."

One better way of keeping heat from leaving the house has been to trap it, using the ventilation system, in a simple plywood box designed by Dr. Bezant, with interlocking vertical channels made of polyethylene sheets. Incoming cold air circulates through one set of channels; outgoing warm air, circulating through another, preheats it. The system saves about 70 per-

Active solar

cent of the heat that would otherwise be lost, savings that would pay for the cost of a box in about five years.

The solar system

The 192-sq-ft solar space and hot water heating collector mounted at 70 degrees on the roof is an Owens-Illinois Evacuated Tube System designed to supply 100 percent of the space heating needs, and 98 percent of the domestic hot water needs. The house does not have a furnace. A three kilowatt heater—about as powerful as two toasters—in the domestic hot-water heater provides off peak electric backup heat if necessary.

The Evacuated Tube System was chosen because it can reduce reflective loss at low sun angles, more of a problem in flat-plate collectors, and it can heat rapidly to high temperatures (an advantage where sunlight hours are short). This is because its efficiency does not drop as rapidly as does that of a flat-plate collector as the difference increases between collector temperature and outside temperature, and because the Evacuated Tube can still make use of diffused sunlight. The tubes look somewhat like fluorescent lamps made of clear glass, nested on curved reflector panels. Inside each, insulated by the vacuum between the glass, is a dark absorber tube that transfers heat to an antifreeze mixture circulating through the collector to carry the collected heat to a 2800 gallon steel storage tank inside the house. At full capacity (88 C, or 190 F), the storage can supply heat for 10 to 15 days. Space heat is distributed by a standard forced-air system; domestic water is heated from storage via a heat exchanger. The system cost \$15,000 installed.

Efficiency at $-20\,\mathrm{C}$ ($-4\,\mathrm{F}$) has been measured at 40 percent, which, except for a few minutes at solar noon, is somewhat less than the manufacturer claimed for it. It is still well within the prepurchase estimates made for it by Dr. Bezant at the University of Saskatchewan.

The system has not been a success, through no intrinsic fault of its own. "We made a complicated plumbing system out of it," says Dr. Bezant. And the wrong pump was used, simply because it was the only one available, not capable of the high head and low flow rate the system needs. The controls were badly located—solenoid



Saskatchewan house's dark cedar, south windows, insulated shutters, and collectors.

valves on the bottoms of the collectors instead of at the top—and there were problems. In addition, the collector was ignored during the summer while tours were made through the house, and it went dry, causing some damage. "Basically, it's a steam boiler," says Dr. Bezant, "and needs similar caution and attention." Because of the difficulties, the system was shut down over last winter and will be modified. Controls will be eliminated and a second pump installed, and plumbing will be improved.

Economically, the system was not a success either. "In a way," says director Wist, "We knew that before we started. We installed the solar system to check." "We will meet such things in the future," says Dr. Bezant, "And it's better to learn the problems now—but if you can design the building to supply 44 percent of your space heating needs through passive solar gain, 33 percent through the waste heat given off by electrical appliances, and 7 percent by the heat given off by the inhabitants, that leaves only 16 percent to be made up by a heating source." The cost to provide that heat with an electrical resistance heating system would be between \$30 and \$50 per year. For comparison, a conventional house the size of the Conservation House would have electric space-heating bills of \$500 annually or gas bills of \$300. Water heating needs in the Conservation House are four to five times those of space-heating needs, making solar systems for domestic hot water more

cost effective. But, "preliminary tests," says Wist, "seem to indicate that at present there are no active systems that are cost effective, when compared with conventional heating systems, for space heat for single housing units in Saskatchewan."

Some results; some economics

The aim of the Conservation House has been to show that houses could conserve energy in the Saskatchewan climate, and that it could be done at prices the average homeowner could afford. Conservation features like those demonstrated would add \$3000 to \$5000 to the construction cost of a conventional house, according to Wist. In four to five years, assuming 20 percent escalation in fuel costs and a 20year mortgage at 10.5 percent interest, the Conservation House owner would have spent less, overall, than his neighbor with a conventional fuel bill. If mortgage and energy bills were combined, the Conservation House is already less expensive to run than a house with electric heat; in four to five years it will be less expensive than a house with gas heat.

The house is almost through the demonstration phase. Then it will go to the Research Council or the University of Saskatchewan for a field test, a full-scale study of the house with a family inhabiting it. Fact sheets on the existing house are available from the Dept. of Mineral Resources, 1404 Toronto Dominion Bldg., Regina, Saskatchewan, SP3 P 5 Canada.

The CSU houses

Colorado State University's five solar test houses built in Fort Collins, Co, have followed—or perhaps led—the development of solar system thinking in the U.S. "We like to think we have influenced it,"

says Dan S. Ward, associate director of the University's Solar Energy Applications Laboratory. The first house was completed in 1974. A 3000-sq-ft story-and-a-half building built into a hill, it was designed by architects Crowther, Kruse & McWilliams

of Denver, and engineered by Ward and Dr. George O.G. Löf, who still lives in an air-heated solar house built to his design in 1957. Insulation is standard for the area: walls, 3½ in. of fiberglass; ceiling, 6½ in. At −10 F, it needs 65,000 Btu per hour.

A liquid-heating collector 760 sq ft in area was installed, built on the site of an aluminum absorber-plate manufactured for the purpose, two double-strength glass covers, insulation for backing, and a frame. The cost was about \$3000 for materials and \$2000 for labor—university labor by workers skilled in unusual construction. Heat storage was an 1100-gallon steel water tank in the basement, enough for about two days of no sun.

About six months later, the University built two more houses, identical except for the solar systems. House #2 got an air system, 736 sq ft of collector using Dr. Löf's Solaron design. A steel absorber plate with a selective surface that increases the heat absorbing capacity heats air passing through a ½-in. space under the plate; the air in turn is blown through an 11′ x 6′ x 5½′ bin holding 25 tons of 1-in. rocks. The rocks absorb the heat, and give it up again when house-heating air is blown through to collect the heat. Comparative studies give it an edge over the liquid system next door.

The third house was intended to be more experimental. It used an evacuated tube system similar to those on the Saskatchewan and MED houses.

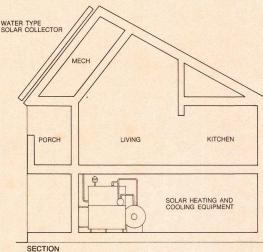
The fourth house, completed in 1977, is a combination residence and greenhouse that uses direct solar gain through windows; the fifth, soon to be constructed, will be passive.

The purpose of the CSU houses being used as offices is to experiment, not to demonstrate. Each set of collectors is up for a year or two, then is changed. Spring





and fall, systems undergo modification. "Most of our effort is spent on systems," says Ward, the interrelationship of collector, heat distribution system, and storage. Last fall, the first solar conference ever

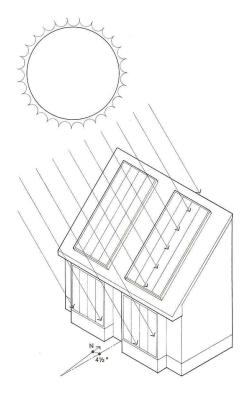


held on the operational results of systems took place in Denver, sponsored by the Department of Energy and the Solar Energy Research Institute. Proceedings are available from NTIS (Oak Ridge, Tn).

Solar One

In 1973, the University of Delaware in Newark, De, built a house that incorporated solar air-heating collectors combined with photovoltaic (electricity-producing) solar cells in a system that heated the house and lighted the lights at the same time. Extra heat was stored in eutectic salts, materials that melt at moderate temperatures and recrystallize at slightly lower temperatures, releasing the heat they soaked up on melting. Extra electricity was stored in a battery, or shipped off to the local utility company via the utility grid.

When photons of light hit certain materials with carefully considered impurities built in, the photons can push electrons around; the moving electrons generate an electrical charge that can be channeled into an electrical system. The photovoltaic material used for the cells in Solar One is cadmium sulfide, not as efficient at turning sunlight into voltage as silicon, but less expensive. Each cell can use perhaps 5



percent of the sunlight that hits it (cadmium sulfide cells have been manufactured with efficiencies as high as 8 percent; silicon cells in laboratories can use as much as 18 percent of the sun). That leaves 97 percent of that sunlight to turn into heat as it hits the cell. And solar cells work better if they are kept reasonably cool. The combination of problems suggests an obvious solution: pull off that extra heat and use it in the house. Solar One had three such banks.

Air moving up the back of the cells is pulled through a 12,000-pound storage bin holding three different eutectic salts, with three different operating temperatures (120 F, 75 F, and 55 F), in sealed, stacked containers, a system designed by Dr. Maria Telkes. The advantage of salts for storage is that they can keep more heat in less space, with less weight. The disadvantage is that they tend to stratify, separate, and otherwise turn uncooperative unless they are knowledgeably handled. The system works—but it's not commercial yet.

The Tech House

In 1974 the National Aeronautics and Space Administration started planning for a solar/energy conservative house using an amalgamation of ideas from HUD, from the National Association of Home Builders (NAHB) Research Institute, The National Bureau of Standards (NBS), the Consumer Products Safety Commission, and NASA itself. Part of NASA's purpose was technology transfer—to see how space technology could be used in housing technology, with products either on the market or close to it. The goal was to cut water and energy use by 50 percent.

The house was completed in 1976. After a period of observation and experiment with the systems a four-person "typical" family moved in, lived there a year, then left. The results of the monitoring done have just been analyzed, and the final report, a technical memo, is scheduled to be made available through the National Technical Information Service (Springfield, Va 22161) in April.

The situation

Hampton, site of Tech House, and of NASA's Langley Research Center, is on one of the peninsulas that nearly closes the mouth of the Chesapeake Bay, in extreme Southeastern Virginia. It has 3400 heating degree days on an average (3900 last winter), and a need for cooling from June through Labor Day. The climate is muggy, the water table is high—but there

are water-treatment and supply problems so severe that recently some water costs were as high as heating costs.

The house

The Tech House is a 1500-sq-ft single-level three-bedroom contemporary house. Its long access is north and south, with entrances opening into vestibules east and west. There are two banks (432 sq ft) of Chamberlain liquid collectors on the roof. A smaller photovoltaic solar collector is located on the garage roof, which is tilted at an angle of 58 degrees. Some attention has been paid to passive solar design—though the overhang that shades the bedroom windows on the south also shades 10 percent of the glass on December 21, and there is no shading on the western windows in the summertime.

A heat pump is integrated with the solar system so that heat from the collectors can go through a heat exchanger into the warm air ducts that distribute heat to the house, or into a 1900-gallon underground storage tank, or through the storage tank to the heat pump. If temperatures in the storage tank drop below 50 F—if, for instance, skies are overcast for more than five to seven days—the heat pump draws from a deep well with a constant temperature of 55 F, and returns the water, its heat extracted, to another deep well.

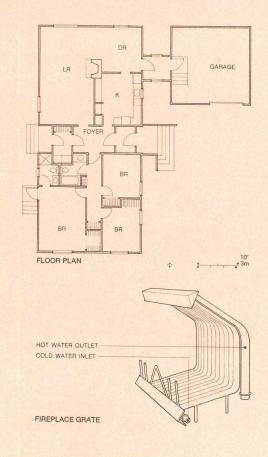
For cooling, the heat pump extracts heat from the house and rejects it to the outside air or to the wells for cooling. Solar storage

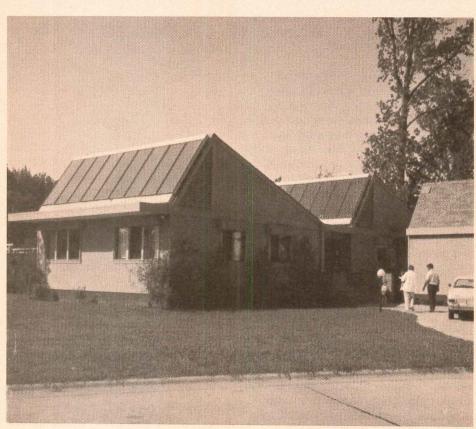
water can be circulated at night through north-facing roof collectors for cooling—a system that has worked better in theory than in practice, because it cannot radiate heat below the dewpoint, and Hampton's night air is damp.

The house is 2" x 6" frame construction, with 5½ in. of nonflammable ureatripolymer insulation (manufactured by C.M. Chemical Co., White Plains, NY) foamed into the exterior walls. Ceilings have 7½ in. of the foam. There has been some shrinkage—more than 3 percent, less than 10 percent—enough to allow more infiltration than is desirable. All windows have double glass and exterior rolling shutters (Pease Co., New Castle, In), operated manually or by electric crank.

Some details

The house has a temperature control system by zones, a solar domestic water preheating system that cuts electric demands for the water heater by about 75 percent, insulated doors with magnetic weather stripping, a security system powered by solar electric cells, and energy conservative household appliances. The fireplace is supplied with unheated air through ducts from the outside; storage-tank water circulates through the grate to pick up heat when the fireplace is burning. This can increase fireplace efficiency from the typical 10 percent to about 50 percent—as good as a sloppily kept furnace, not as good as an airtight wood stove. A skylight over the





hallway cuts electric heating needs, and can be used as a vent in spring and fall.

Some results

Few other demonstration projects have so closely monitored the interaction of a real family with a real solar system. "Problems cropped up. We found a lot of them," says Ira Abbott, NASA project manager. "That should not be looked on as an adverse thing. The solutions should make solar pay for itself." The project hit its 50 percent energy conservation goal with 1 percent to spare.

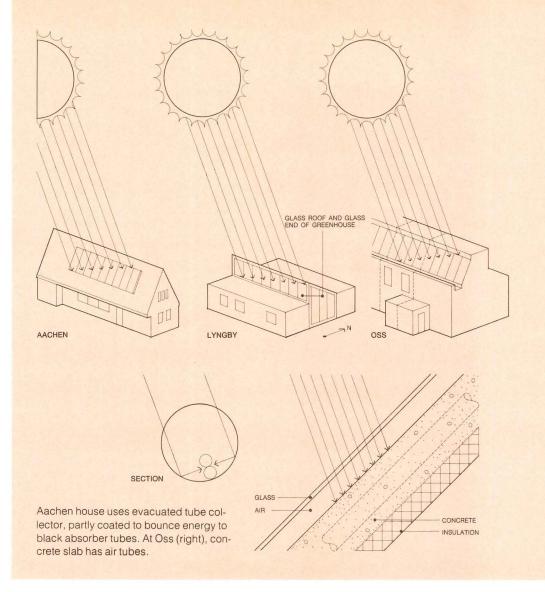
The two difficulties that most affected the performance of the house were the architecture and the solar storage system. The short wall faced south, so less sunlight was picked up directly. The overhang, partly for aesthetic reasons, cast its shadow in the wrong place at the wrong time of the year. Snow can pile up on the flat parts of the roof, blocking the collectors and lowering their efficiency. The skylight is a net heat loser, for questionable benefits in spring and fall. The insulating envelope around the underground storage ground was breeched—it can easily happen and is very difficult to correct once the tank has been installed—with the result that ground water carried away a sizable amount of the solar heat collected. Hybernating worms were probably very happy. Collector performance, after three years, has been fine. Overall, the solar system provided 35 percent of the house heat, instead of the projected 70 percent, almost all of it attributable to storage loss.

The solutions to these problems, with hindsight, are simple and obvious: closer attention to passive design details, perhaps a more functional definition of aesthetics; a storage tank integrated with the building so that losses are to the building.

Lyngby, Aachen, Oss

Neither the CSU houses nor Solar One has paid extraordinary attention to energy conservation, in part because the researchers wanted results of solar systems on "ordinary" houses. But the energy conservative demonstration houses in North America have drawn to some extent on extraordinary houses in Denmark, Germany, and the Netherlands. All three are industry/government or university projects.

The Zero Energy House at Lyngby, Denmark, is a student-designed and built project of the Technical University of Denmark's Thermal Insulation Laboratory. Two single-story living modules with flat roofs sandwich a 1½-story greenhouse atrium that provides support for 450 sq ft of vertical water-heating collector on its south face. The collector is drained when temperatures are below freezing, so the circulating liquid can be plain water. Storage is water, in a cylindrical steel tank buried



outside the house—8000 gallons, nearly four times the typical amount for a U.S. solar system. Heat is collected all summer, so that storage temperatures at the onset of the long, foggy, dark winter are about 50 C (122 F). The tank loses nearly 41 percent of the 9017 kWh of heat it gathers, but there is enough left to supply 100 percent of the house heating and hot water requirements.

This is partly because the house needs less than 1/6 the heat required by a conventional house of similar size. Twelve to 16 in. of mineral wool insulate walls and ceilings. There are few windows, even on the south side, and these are insulated at night by insulating shutters, or by polystyrene bubbles, blown into the cavity between the two layers of glass. Most windows do not open. Air-to-air heat recovery devices recycle heat from ventilation, appliances, and people. A heat exchanger extracts the heat from waste hot water.

The Philips Forschungslaboratorium house in Aachen, Germany, is a high-tech approach, and a workshop for collectors similar to the CSU houses. Several U.S. collectors have been tested there. The 1250-sq-ft 1½-story house is also superinsulated, with waste heat scavenged by a number of heat exchange systems. Stor-

age is in 11,000 gallons of water in two tanks, one a 1000-gallon short-term storage tank, the other for longer-term storage. Heat can be pulled from storage directly, or by means of a heat pump. The first collector to go on the house was the Philips' own version of an evacuated tube, capable of surviving stagnation temperatures of 250 C (482 degrees F). Cooling in summer is by means of water circulated through pipes buried deep in the constant-temperature earth. Like the Zero Energy House, the Aachen house gets 100 percent of its heat from the sun.

The Bouwcentrum Co. houses in Oss, 50 miles east of Rotterdam, like the other two European houses, were completed in 1975. This is a demonstration of low-cost solar housing. The four row-houses, each 2100 sq ft (200 sq m), face south and are insulated to a thermal transmittance value of 0.8 kilocalories/h/degrees C m2. The 270 sq ft (25 sq m) of collectors—an 11-in. concrete slab, black-surfaced, with air channels embedded in it in two houses, and water pipes embedded in the other two houses—are mounted on the 60degree slope of the typical Dutch rooftop. The concrete collector is also the storage. The system will provide about 40 percent of the heat the houses need.

MEDI&II

The Minimum Energy Dwelling project in Mission Viejo, a planned community 50 miles south of Los Angeles, was conceived by the Southern California Gas (not, they repeat, not electric) Co. in 1975. The point was to explore some of the possibilities of off-the-shelf products for massproduced and middle-income (in California terms, where a \$75,000 house is considered a bargain) energy conservation housing. This is the only one of the demonstration houses to face the reality of mass-produced housing construction. Mission Viejo, Inc., one of California's larger developers, started its 25-year building project in 1973. It is, according to James Boulware, chief architect, one of the more energy conservative developers, "because we're going to be here a long time." With Southern California Gas they built two units modified from one of their standard plans with energy conservation and solar heating and cooling. These are MED I. The Department of Energy contributed \$230,000 to the study, for monitoring and for the production of a workbook version of the MED ideas suitable for widespread use. The final report is due to be issued this month through DOE's National Technical Information Center (Oak Ridge, Tn). Mission Viejo took the most costeffective of the ideas explored by MED I and built MED II. Some changes were made, some things were learned. Mission

Viejo will shut the program down next year. "It has served its function," says Boulware. The aim, then, is a line of houses that incorporate MED features.

The house

The two 1042-sq-ft three-bedroom houses—one for demonstration, one for "typical" family occupancy and studyare built side by side on Nogal Drive, on the northern side of Mission Viejo's 10,000 acres. Burt, Hill & Associates (now Burt Hill Kosar Rittleman Associates), architects for the project, chose Mission Viejo's Cordova house, Plan 20, as the base for the design. The aim was to cut all kinds of energy consumption in half.

Infiltration and insulation: exterior walls are built of 2" x 6" studs, 24 in. on center, a change that added no cost to the house because the wider spaces eliminated some studs. Six-inch batts of fiberglass (R-19) were used in the walls; ceilings are insulated to R-26, although less insulation could probably have been used in this climate. Cracks around windows and between studs were stuffed with fiberglass. Mastic was applied as a sealer between slab and sill, and the slab was insulated outside with 2 in. of rigid polystyrene. The building paper on exterior walls was replaced with 6-mil polyethylene, over which the chicken wire and stucco were applied. (The vapor barrier is outside the insulation because cooling accounts for 90 percent

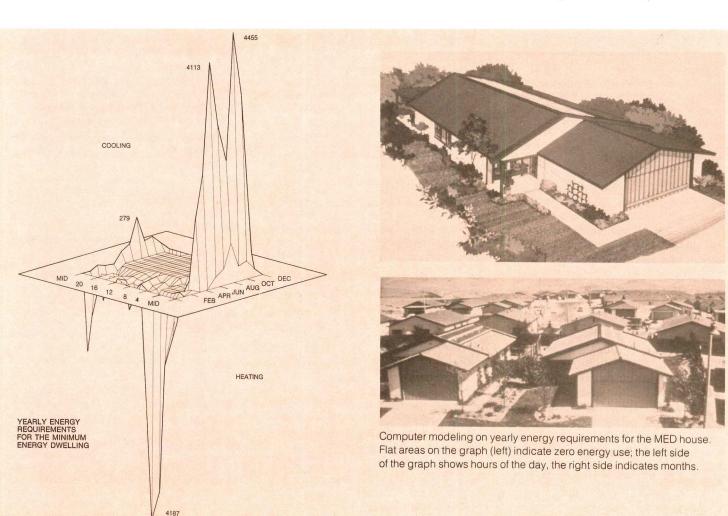
of the house needs for climate control.) Preliminary results indicate the infiltration losses have been cut by a third.

Structural and material modifications: because cooling is so important, MED I emphasizes shading—by wall angles, by the roof overhang, by a patio cover. Western windows have vertical wings to keep sun out, and light-colored walls reflect sunlight, reducing heat gain. Windows are double-paned. The front door is foam-filled steel. The roof is heavy red tile, its mass intended to delay the incoming sun's heat.

Cool outside air is brought in for cooling wherever possible, through the use of an economizer cycle. Sensors check temperature and humidity, sending fresh air through the air-handling system when conditions are right; savings of up to 60 percent for cooling have been indicated. The cycle is tied in with the solar system.

The Solar System: Because solar cooling was a specified part of the project, a high-temperature solar system was necessary to run a three-ton absorption cooler, the smallest American unit commercially available. MED I used 320 sq ft of evacuated tubes and 500 gallons of storage capacity for each house. The system, however, has not proved to be cost effective. The economizer cycle can, in this climate, manage things on its own.

The second step of the project, another modified Plan 20, has just been completed and is being instrumented by Southern



California Gas. Things have changed somewhat, for cost reasons and in response to the realities of assembly line construction. For instance, those nice tight-sealing steel insulated doors: wooden doors can be adjusted in installing them; steel doors can't. The finish on steel doors is like the finish on a car. It is sprayed, and it can scratch or dent. If it does, the paintbrush used to touch it up leaves marks. Mission Viejo has gone back to wood. With MED II, Mission Viejo also went back to 2" x 4" studs, adding a polystyrene exterior insulation sheath. But Southern California construction workers are not used to sheathing; in addition, there was damage by vandals. It probably will not be used again. The Pella windows needed painting—a \$60 cost that looks exorbitant in an era when builders pinch pennies by shaving the sizes of porch railings. But they will be used again.

The economizer cycle has been included, along with heavy insulation and double-paned glass, and there is a solar-assisted domestic water heater. The biggest innovations are greater use of passive solar elements in the design, and a British boiler hydronic heating system, the kind called geezers in England, for water heated on demand.

Energy conservation in Southern California, according to Mission Viejo architect Boulware, is only a selling point if you can prove to the buyer that it will pay for itself. Because that buyer is so mobile, systems need three- to five-year break-even points.

According to Christopher Johnson, project architect for Burt Hill who is now with the Architectural Alliance, one major conclusion hidden in the report is the fact that energy conservation remains very much a matter of life style. Although MED I exceeded its goal, cutting 51 percent from energy consumption by the house, and MED II will probably achieve its goal of 40 percent reduction, the "typical" inhabitants, a couple with one child, one-and-ahalf jobs, and two cars, used more electricity than other households in the Mission Viejo community.

Conclusion

The Mission Viejo Project, with its \$230,000 federal money for monitoring, is one of the Dept. of Housing and Urban Development's Residential Solar Heating and Cooling Demonstrations. The demonstration program, now just about complete, gave money and publicity to some 5000 residential units—perhaps 40 times as many solar houses as existed in the U.S. when the program was first designed in 1974, and a sizable chunk of the estimated 40,000 units that exist now.

The goal of the HUD program was commercialization, part of an effort by

then-ERDA (later DOE) to shorten the 25to 50-year time gap between the introduction of the technology (say, for example, television in 1927) and its widespread acceptance (a set in one house out of ten by 1950). That gap begins to look like a law of nature. Problems have plagued the demonstration program—nothing big enough to make front-page headlines, just niggling difficulties that appear on the business, financial, and home pages, where potential home buyers and investors notice them. The five cycles of the HUD program were carefully and probably intelligently designed to fit what government planners with good intentions and a fair amount of expertise saw as the basic necessities. Each cycle was to establish one step and explore the next. Each was perforce a further kind of partnership among various representatives of what government likes to call the private sector. Each was to spread training and knowledge as it refined manufacturing and design. But besides the usual bureaucratic hassles (paperwork, insistence on particular kinds of detail, money arriving late, etc.) there were problems in almost all the other areas. 1) Persistent materials and design problems: Case histories are being collected, examined, and analyzed by IBM at Huntsville and Argonne National Laboratory, among others. Data are being released as they are processed through the National Technical Information Center at Oakridge.

2) Shipping problems: A service association for industries that do extensive shipping is opening a branch to deal specifically with solar shipping problems. Damage during shipping has been known to run as high as 30 percent of the shipment. 3) Codes and standards problems: The cycles of the HUD program coexist with major efforts by BOCA and the other major code-writing organizations to identify and codify specifically solar situations. The National Bureau of Standards, using a speeded-up version of its normal standard setting procedure, is working to develop solar equipment standards; both speed and what seems to some to be a lack of speed have caused controversy in the solar industry and some questionable decisions. The Dept. of Commerce, using NBS data, has been working simultaneously to evolve minimum property standards that apply sensibly to solar.

Surprisingly, legal problems (sun rights, legislative work, jurisdictional questions) and financial problems (lending institutions' willingness to lend) have been less evident than had been expected. One Santa Fe, NM, bank—admittedly in an area of intense solar building and solar educational efforts—made seventeen loans for passive solar houses in the month of De-

cember 1978 alone. Passive solar use probably demands a somewhat more sophisticated understanding on the part of the banker than active solar use does. Three-fourths of the states have passed solar legislation, usually favoring solar through some form of tax break.

But the problem of solar economics is turning out to be fearsome. Solar people at ERDA once thought that the nonsolar world would begin to see the sun as sensible when collectors could be had for about \$10 a sq ft. That still seems a possible cost for some forms of plastic collectors, but the cost is now running in the neighborhood of \$50 a sq ft installed for most of the systems on the market. The long delay in passage on the National Energy Act, including tax credits for solar use, hurts solar manufacturing badly as customers who had decided to go solar waited.

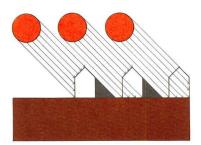
The HUD demonstration program, instead of spreading interest in solar use, may just have skimmed the cream from an already interested solar market, so that manufacturers who developed their capabilities under that program—and who benefited from hard-learned lessons in materials, design, and installation—now have to scramble to stimulate demand for their supply. At least two of the four largest manufacturers added capacity to double their output, but that capacity is still idle. And while the course of world politics (Iran and all that) has gone rather predictably, U.S. energy politics have been disastrous. Nothing has happened; life goes on the same as before.

All in all, solar manufacturing is in trouble and has been for the past year or so. Traditional commercialization forces may be at work—small business innovates, struggles, staggers, dies; big business delays, then buys the best of the innovation, capitalizes it, and takes over the market. New directions may change the situation: work being done on plastic collectors, on community use of solar energy, or on solar ponds, could shift the economic picture dramatically. The retrofit market is wide open. Owners of all the existing buildings in the U.S. will know it, perhaps by the middle of next winter, if prices for conventional fuel do what it seems likely that they will do. In fact, the retrofit market seems to be the most promising for active systems, and concentrated attention should be given to solving problems of match between conventional house design and heat distribution systems, and solar supply and storage needs, for existing houses.

All in all, it may be that there is substantial competition between conservation and active solar systems for the future energy market in the United States—and manufacturers of active systems should be aware of it.

The heat also rises

J. Douglas Balcomb



A leading passive solar heating expert advocates proper more extensive uses, outlines various familiar approaches and evaluates many existing built examples.

The increasing adoption of passive solar heating will greatly affect architectural design within the next few years. A number of concurrent trends already point in this direction: Designers, builders, buyers, and financing organizations—all parties involved in the energy problem—are increasingly aware of the notoriously poor thermal efficiency of our buildings. Passive solar heating presents a worthwhile solution to this problem throughout the entire range of climates in the United States. Although less explored, natural cooling techniques could probably work as well in most locations. Additionally, passive solar heating and natural cooling can be achieved easily by design in harmony with the surroundings, thus offering comfort, economy, convenience, and aesthetic appeal with little problem.

Unfortunately, so far, lack of awareness of these advantages still exists. Often energy conservation measures have resulted in simple-minded solutions incorporating thick, fully insulated walls of lightweight construction and minimum glazing. Furthermore, energy-conserving building codes are trying to institutionalize and enforce this regressive approach. Many clients, builders, and architects still do not realize that energy consumption can be reduced below the levels achievable with these energy-conservation measures through effective mix of both conservation measures and passive solar heating techniques.

Passive solar heating approaches

Basically, a passively solar-heated building depends on the transmission of heat by natural means—by natural convection,

conduction, or radiation. No fans, pumps, or outside energy other than the sun need make this "system" operate. But the building must integrate the means to obtain solar heating into the design of the building. Major components frequently perform dual roles—for example, glazing may serve as a solar collection element that allows light and air into the interior, or the mass of the building may provide heat storage as well as shelter.

There are five different generic approaches to heating by passive solar methods that can be used alone or mixed together, depending on architectural requirements and client desires. The differing approaches work well together thermally since each tends to deliver heat at a different time and in a different manner. Thus solar heating can be matched to the load by an appropriate blending of system types.

Direct gain: The direct gain approach to passive solar heating is the simplest and most frequently used. Winter sunshine enters south-facing glazing to be absorbed and stored in a mass within the building. If more sunlight enters than is needed during the day, and if solar heat provides more than 40 percent of the heating requirement, thermal storage becomes particularly crucial. A masonry floor can store heat only if it receives direct radiation from the sun. A wall—insulated on the outside—also can be harnessed for heat storage.

To take advantage of heat gain, double glazing facing south on a vertical plane provides the most favorable means of capturing energy passively for most regions in the United States. Sun angles at different times of the year work well for passive solar heating: the low sun angles, of course, mean that solar gain is at a maximum in the winter; the sun angles in the summer, on the other hand, are 47 degrees higher. Small overhangs reduce

heat gains through glazing in the summer, with little sacrifice to winter heating. One can cut down on heat losses at night by insulating windows through a variety of means such as insulating shutters and well-designed drapes.

Thermal storage wall: The thermal storage wall method involves placing a mass wall immediately behind the double glazing, to make maximum use of the heat gain and reduce large temperature swings from day to night. The thermal storage wall can be made of any material that has high conductivity and heat storage capacity. Often masonry or containers of water seem to be favored.

In 1967, Felix Trombe popularized a masonry or concrete thermal storage wall concept, which had been invented much earlier, with his test house in the Pyrenees. There he located a 2-ft-thick concrete wall behind fixed double glazing that provided 70 percent of the house's heating requirements, while keeping heat inside at 68 degrees. Openings in the wall at the top and bottom allow hot air to circulate through the space, then return when cooled. The device, used for this cold but sunny mountain climate, proved so impressive that the masonry thermal storage wall is now widely referred to as a "Trombe Wall."

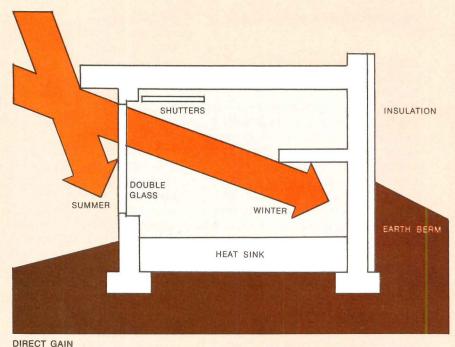
Storing heat in containers of water presents another method, popularized by Steven Baer with his Albuquerque home. There he used 55-gallon drums for the water containers. Now a variety of waterstorage-wall ideas have been developed with every kind of container from acrylic glass cylinders, to boxes or metal culverts. The water container allows a higher heat storage capacity per volume than other methods. A mixed passive approach that combines a thermal storage wall with the direct gain method can be attractive as well as efficient. The direct gain provides heat during the day while the thermal storage wall provides a maximum of heat delivery in the evening. This balance, especially valuable in residential applications can be seen in the Santa Fe subdivision, First Village (p. 110). As Unit 3 (p. 113) illustrates, clerestory windows centered in the roof bring light and heat into the northern part of the house where a north-facing bermed concrete wall provides thermal storage. The south Trombe wall is also concrete, 16 in. thick. To provide both direct heat gain and view to the south, several windows were placed in the Trombe wall. On the outside, double-glazed lights cover the entire south wall of the house. Sealed and tempered, they use standard 34" x 76" and 46" x 76" sizes set in wood mullions, with about a 3-in. space between the glass and the surface of the Trombe wall.

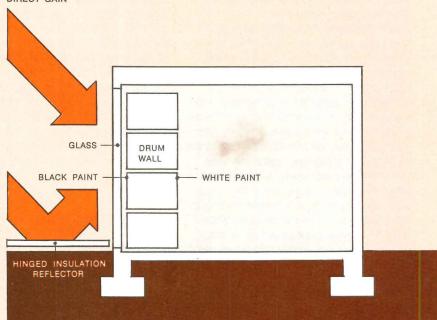
This surface is painted black, though it could have been any dark color. The dark concrete surface absorbs the sunlight and heats up to a maximum temperature of 160 F during clear days. Since the glass traps the heat, the majority of the heat can pass directly into the wall surface. The heat, as it is stored by the wall, moves gradually through to the inside surface. Thick walls not only store more heat but reduce the fluctuation in temperature of the inside surface. But since heat is lost through the glazing at night, the total amount of heat energy transmitted to the inside wall surface will usually amount to little more than about 35 percent of the solar energy that hits the outside surface.

Masonry Trombe walls can be made of concrete block in which core holes are grouted, grouted block with brick facing, or adobe earth bricks. Usually a high density maximizes thermal conductivity and heat storage capacity.

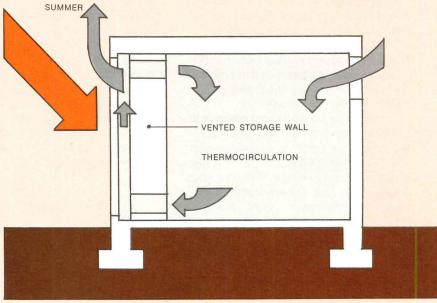
Attached sun space: The third method for passive solar heating is the use of attached sun space, a hybrid of the direct gain and thermal storage wall techniques. Basically, a space separates the southfacing glazing and the mass wall. On the other side of the mass wall is another living space that obtains heat from its conduction through the mass wall. While the attached sun space will be more subject to large temperature swings, this space can be used as a greenhouse, sun room, or conservatory, as well as a passageway or air-lock entry. Obviously this kind of area offers more possibilities with regard to living patterns than does a Trombe wall behind the south-facing glazing. Thermally the attached sun space offers advantages in the reduced temperature swing in the portion of the building to the north of the mass wall owing to the wall's time delay and heat capacity effects. With a little care in the design, one can phase the time of heat arrival in this northern zone to maintain a nearly constant temperature.

Because of the climate, examples of the





THERMAL STORAGE WALL



TROMBE WALL

4.70 December 4.00

Principles of passive solar heating

effective use of the two-zone approach abound in Santa Fe, such as Unit 1 in the First Village (p. 110). At an elevation of 7000 ft, Santa Fe's heating degree-day requirements match those of Chicago, with frequent winter snowstorms, with 70 percent of possible sunshine. Scientific monitoring shows that the sunshine provides 92 percent of the heat in Unit 1, with auxiliary heating furnished by the fireplace and baseboard electric units. The required electric heating approximates 857 kwh for the winter season.

The solar greenhouse concept, popular as a method of solar heating, can supply all of the heat required by the greenhouse and additional heat for the home, even in severe climates. Many people prefer these greenhouses to grow vegetables and flowers throughout the winter—in addition to solar heating advantages.

Roof pond and convective loop: The final two passive solar techniques, a roof pond and a convective loop, have been used less than the previously described approaches. The roof pond, or thermal storage roof, calls for the placement of the mass on the ceiling rather than on the side walls. With this approach to heating, effective cooling can be provided as well: radiation out during summer nights removes unwanted heat efficiently, as long as the pond has been covered in the day. Thus the insulation must be movable. Sliding insulation panels or similar devices placed over the thermal storage at night in the winter and during the day in the summer solve the problem of seasonal excesses in heat gain or loss.

The convective loop method for passive solar heating involves ducts and pipes between separate collector and thermal storage areas, much like normal active systems. If the collector is located below the thermal storage wall, then the heated fluid will rise by natural convection, deposit its heat in the thermal storage, and return by natural convection to the collector. The classic thermosiphon water heater works this way. Buildings have used this method with air as the working "fluid" and a rock bed as the thermal storage.

By attaching the air-heating collector to the south side of the building, one can make effective use of the convective loop. Warm air is fed to the building during the day through an opening in the upper duct, and a simple passive backdraft damper prevents the flow back at night. This approach works particularly well for situations where major heating needs occur during the daytime and little heat storage is needed for nighttime temperatures. For a diagram of the convective loop methods, see opposite page, top left.

Hybrid systems

For many kinds of buildings, both approaches to solar heating are commonly put to use. Combinations of active and passive solar heating systems are generally referred to as "hybrid." The atrium sun space in combination with fan-forced rock-bed heat storage offers a common example.

Another hybrid approach, of course, involves the addition of active collector and remote storage units to a building designed as a passive solar building. This approach looks most feasible if one designs the building to receive 40 to 60 percent of the heat from passive solar means, then supplements it with an extended domestic hot-water system that provides an additional 20 to 30 percent of active space heating.

Performance

A majority of a building's heat can be supplied by passive solar methods in the milder U.S. climates, with such simple means as proper attention to building orientation and siting, and effective use of south-side fenestration. The normal mass already present, even in frame construction and interior furnishings, often provides some heat storage. In colder climates, more explicit passive solar methods need to be used, with careful attention paid to the type and place of the heat storing mass to obtain a high solar heating fraction and maintain the heat at a comfortable level.

In small structures, heating requirements can be affected more by the building envelope and normal air-exchange requirements than by elements generating energy and heat such as light, people, and equipment. Here, simple sizing rules can be applied. Based on mathematical models, these rules have been confirmed by data taken on monitored passive solar buildings as well as small test rooms.

An example of expected performance characteristics illustrates how effective passive solar heating methods can be throughout an extreme range of cold U.S. climates. Let's take a 1600-sq-ft house with a 400-sq-ft Trombe wall, 18 in thick, facing south. The Trombe wall glazing is double and is insulated at night. The building is well insulated and has a total design heating load of 32,040 Btu per hour at a design temperature of 5 F. The predicted performance goes as follows:

Fraction of total heat supplied by solar Boston, Ma 58% Albuquerque, NM 80% Cleveland, Oh 49% Madison, Wi 50% Seattle, Wa 62%

64%

Washington, DC

This performance can be maintained even if some of the Trombe wall is replaced with direct-gain windows.

Costs

Typical costs associated with residential passive solar construction, over and above normal costs, range from \$2000 to \$6000 (or 2–10% of construction). Incremental add-on installed costs generally fall in the ranges shown below. Costs are based on per sq ft of glazing for solar collection.

Direct gain	\$2-11/sqft
Thermal storage wall	\$8-18/sq ft
Attached sun space	\$5-15/sqft
Thermal storage roof	\$10-25/sqft
Convective loop	\$5-8/sq ft

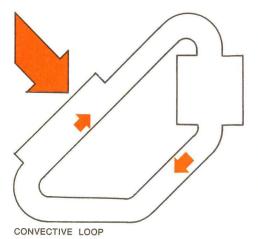
These costs vary depending on the location and construction of the building, materials, workmanship, finishes, and means employed to provide insulation and cut heat losses at night. This cost, generally ranging from \$4 to \$10 per sq ft, is included in the ranges of figures given above.

Costs tend to be low for passive systems primarily because the materials are available, the infrastructure required for the manufacture and distribution of the materials is already in place, and builders are already familiar with their use. The most commonly used materials in passive solar heated buildings include glass and masonry, both materials that perform other functions (such as admitting natural light, or holding up the roof).

Livability

Many people tend to believe that occupants of passively solar heated buildings have to change their lifestyles to cope with the temperatures within. The myth holds true only in poor designs. By proper design and the effective use of thermal mass, architects can create livable and comfortable spaces open to their natural surroundings, thus increasing occupants' awareness of the environment.

Perhaps a radiant panel that emits heat at low temperatures presents the most comfortable solution to heating a building. Heating fluxes are relatively low, with no unexpected hot or cold spots, drafts are eliminated, and there is no noise. A wellinsulated room can be heated easily by keeping any one of the side or floor surfaces at a temperature no greater than 80 F. The heat radiating from a sidewall surface causes natural convection of air within the room between the heated surface and the slightly cooler surfaces. The convective air current moves slowly enough to be imperceptible to the occupants, but sufficiently to maintain a good mixing of the air and prevent stratification according to temperatures.

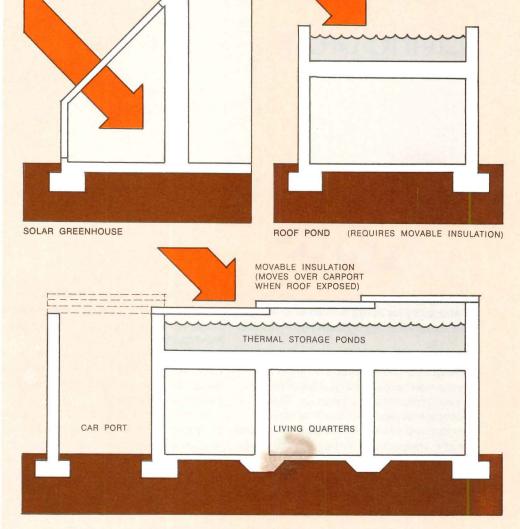


While the thermal storage wall and direct-gain passive approaches most commonly associated with radiant heating are commonly used, it has to be acknowledged that there are more efficient ways to heat space radiantly than by heating the air. The effective comfort temperature is divided about equally between the mean radiant temperature (a calculation meant to approximate the effect of surface temperature on thermal comfort) and the air temperature. If the mean radiant temperature can be maintained at a high level, then the air temperature can be kept fairly low without loss of comfort. Thus the energy required to heat air flowing through the building—which accounts for a significant portion of the energy requirements of a new, well-insulated house—can be substantially reduced in a space heated predominantly by radiant energy.

One must be careful in passive solar designs to avoid large cold surfaces within the room. Expansive glass areas do require relatively high air temperatures to offset their cooling effect. A design that includes a lot of glass—necessary of course with direct gain systems—simply has to make use of movable insulation panels, drapes, triple glazing, or other such devices that prevent heat loss.

Actually, the application of large expanses of glass already commonplace in modern architecture does not diverge too much from the glass walls or clerestory windows found in passively solar homes. Opening up interior space through clerestories or skylights means that plants can grow and space can be dramatically modulated with natural light. Massive fireplaces in buildings can be put to good thermal storage use by virtue of the building's geometry and orientation. Other features, such as overhangs and shutters, present possibilities for architectural variety while offering solar advantages.

Although architectural design has never been static, the increase in the use of passive solar approaches adds a new dimension to design, a synergy that could herald a revolution in architecture as we know it.



Research at Los Alamos

The Los Alamos Scientific Laboratory (LASL), located at 7200 feet in the mountains of northern New Mexico, has been the focal point of the Department of Energy's research and development activity in passive solar heating. The LASL initiative in this area was responsible for getting the DOE program started, and a major portion of findings published has resulted from its work. Partly as a result of LASL's urging, a number of parallel research and development projects have now been initiated at many other places within the United States.

The primary objectives of the LASL program are to perform a detailed evaluation of passive solar heating and to provide a quantitative procedure that will enable building designers to incorporate passive solar heating into building design. The work falls into four key areas: experiments in passive solar test rooms; monitoring of passive solar buildings; computer simulations and system analysis of passive solar concepts; and development of design tools.

Fourteen passive solar test rooms have been constructed at Los Alamos with detailed data taken under carefully controlled conditions. These findings enable computer simulation models for thermal storage wall and direct gain test rooms to be formulated. Future work will concentrate on different design approaches such as convective loops, attached sunspaces, and thermal storage roofs, plus the extension of experiments on a variety of advanced concepts for improved performance.

In addition to the test rooms, instruments have been installed in 15 buildings representing a variety of passive solar approaches. Data retrieved from these more complex situations are being incorporated into computer modeling processes. Already data from three buildings have been

analyzed extensively and the model validation process has proved successful. More detailed information on convective flows, temperature distributions, and thermal comfort conditions will allow a more thorough understanding of energy flow mechanisms in passive solar buildings. Thus, present research emphasizes this particular area of data gathering, rather than say the monitoring of more buildings.

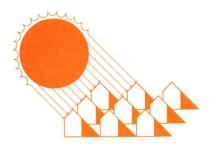
Computer simulation analysis ties the experimental and monitoring work together for broader application. Only through such tools can the results be generalized, design methods be developed, and the effect of both climatic conditions and design factors be quantified.

Once faith has been established in a mathematical modeling approach, then a complex computer model can be assembled representing a particular class of buildings. This model can be used for systems studies—climatic studies and parameter variations.

LASL performs a full-year hour-by-hour simulation of building designs for 29 different climatic conditions. The hour-by-hour simulation techniques can also be used to determine the influence of various design parameters. On this basis, important performance and economic decisions can be made in order to choose the most appropriate systems for each climate and to develop designs accordingly.

LASL has made significant progress in using the complex models to develop simple design techniques, with the results of many hundreds of hour-by-hour analyses used as a basis for determining correlations. This process has been carried through to completion for direct-gain and thermal storage-wall designs, and the procedure used successfully as the basis for evaluation of the recent HUD Passive Solar Design Competition and Demonstration (see p. 26).

Living proof



A cluster of houses in Santa Fe offers a laboratory for living with solar heating by experimenting with several methods.

Santa Fe could be called the hotbed of solar heat housing. In this area of adobe walls, pueblo style architecture, 70 percent sun all year around, a new regional type of architecture is taking shape—some call it "solar adobe." While many of the designers, architects, and builders started out experimenting with "active" solar heated environments, "these days you find nine out of ten switching to passive solar heating," guesses one staunch convert.

Susan and Wayne Nichols count in this number, for they have developed, designed, and built a solar-heated housing subdivision in Santa Fe that is both a model for different kinds of heating approaches and an experimental laboratory to test out the best kinds of solutions. Because solar scientist Douglas Balcomb of the Los Alamos Scientific Laboratory (p. 109) lives there, much of the information being gathered can be translated directly into computers.

The Nicholses, with Douglas and Sara Balcomb and Albuquerque architect Edward Mazria, in fact have formed Passive Solar Associates. This group travels to various cities giving workshops on solar heat and its movement by natural (passive) means—conduction, convection, and natural circulation, through any number of methods such as water walls, Trombe walls, clerestories, greenhouses, and direct gain. These designers, developers, and scientists obviously believe in spreading the word.

The Nicholses began to see the development potential of solar heated housing in 1973 when they relocated to Santa Fe from California. Wayne, a Harvard-trained businessman, and Susan, a Stanford University-trained mathematician,

made the transition into architecture and development of solar heated houses rather smoothly. They first began as part of the Sun Mountain Design group with architects and designers Bill Lumpkin, David Wright, Travis Price, Keith Haggard, and others, then proceeded to build their own active solar home.

And soon they formed their firm of Communico Inc. and bought a 40-acre tract of land on which they planned two clustered developments sharing common open space. Owing to costs and marketing factors, the Nicholses changed the program to eight luxury-priced homes on five-acre plots. This community, called First Village, lies six miles south of Santa Fe. Beginning work on two houses simultaneously—the first solar homes built on speculation in New Mexico—they decided to design one according to passive solar heating methods, the other according to activewith a solar collector. Both houses (the Balcomb House and the McDowell House) proved marketable, although it has become clear that the passive solar house was not only cheaper and easier to build but lower in cost to maintain than the active one. The rest of the houses, of which five were built on spec and three for clients, employ passive solar heating methods and construction.

Because of the experimental nature of this kind of housing, the Nicholses geared the development to a professional affluent market that can afford homes in the \$100,000–\$170,000 range. The buyers of these homes often tend to be in their thirties and forties, some single, some with small families, all with individual lifestyles and strong environmental concerns. Like the passive solar designers and builders, this community seems convinced about and committed to passive solar heating.

Now that the Nicholses have reached a point where they can easily identify which combinations of passive solar heating and



natural cooling work best, they plan to pursue lower-cost housing developments. With their next project, La Vereda, they are building 19 passive solar homes in a planned unit development of quarter-acre lots on five acres, with five left as common space.

These two- to three-bedroom houses will range from homes 1100 sq ft in size, priced around \$80,000, to ones about 1950 sq ft selling for \$110,000. In a sense they hope the "standardization" benefits seen in manufacturing will operate: that as the alternate technology designs become more refined, lower-cost passive solar housing can reach a broader public. Right now they face the problem that some solar (passive and active) homes work well but cost 15 to 20 percent more than conventional houses. As Wayne Nichols pithily states, "We know that the passive solar home costs more and anybody who says it doesn't has never built one." To keep costs under control, Communico Inc. uses its own building crews as much as possible—with only plumbing, electrical work, and roof construction subcontracted. Whereas costs in First Village ran about \$48 per sq ft because of the prototypical nature of their design, with La Vereda they think they can keep the price

to \$40 to \$42 per sq ft with a 15 percent overhead and profit. Nevertheless, with the houses selling for less money, there is less margin to offset the risk. Furthermore, the buyer will be getting about 200 to 300 sq ft less space for the price in return for passive solar features.

The Nicholses do run into obstacles, of course, in these incipient years of passive solar construction. Appraisers and mortgage companies tend to be conservative, requiring a course in passive solar methods before they will take the risk. It is to Communico Inc.'s benefit that it can provide engineering and financing figures, along with a crash course in solar heating. Susan Nichols does most of the design assisted by architect John Pryor.

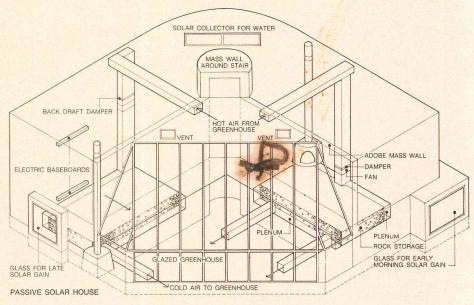
In the initial work of the Nicholses shown on these pages, certain architectural features go hand in hand with their passive solar approach. Clerestory windows, stagnated Trombe walls with direct gain expanses of glazing, and greenhouses have become a prevalent trademark—a definite architectural character. Other features, such as sinking the houses partially into the earth, using thick-walled construction, or including many fireplaces, are less obvious, because they are less visible and are more historically familiar.

The style the Nicholses work in (solar adobe) represents an amalgam of the regional pueblo style with its adobe walls (usually stuccoed), vigas, and chunky forms. So far the grafting of solar technology onto a regional vocabulary lacks a sense of refinement in the formal integration or at the level of detail—a characteristic generally true of other work than just the Nicholses'. If anything, their schemes offer more of a sense of integration, and their designs are often more refined, functionally and spatially. Still the inclusion of a Trombe wall, for example, into the pueblo style leaves something to be desired.

Even if solar adobe becomes a "style" with a degree of architectural sophistication, it still makes sense only in this regional context. Other architects are developing an architecture incorporating the passive solar components for other areas. (For more discussion about regional solar architecture see p. 144.)

Of course the other main question that comes to mind with regard to this effort centers on the single-family home versus multifamily housing. Row housing with shared party walls would make better use of solar heating techniques. Can that kind of development gamble be taken soon? The Nicholses are to be commended for striking out in this new terrain of housing development, and for advancing the design and construction of solar architecture this far. They—and others—will no doubt advance this effort even further. [Suzanne Stephens]





The Balcomb house (Unit 1)

Built on speculation, this house, now owned by Douglas and Sara Balcomb, was designed by Santa Fe architect William Lumpkin with Susan Nichols. It represents a hybrid passive solar approach, using the direct-gain method of introducing the sun into a 400-sq-ft double height greenhouse, backed with a thermal mass wall of adobe brick, 1050 cu ft and 10 to 14 in. thick, with a heat storage capacity of 25,200 Btu per degree F.

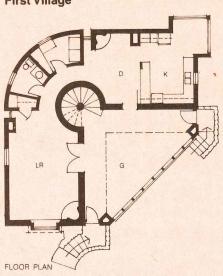
The living areas on both levels have openings onto the greenhouse otherwise separated from them by a mass interior wall that also wraps around a central stair. Spaces from both levels thus receive the sun's heat, stored in the wall and then reradiated after a delay of about ten hours. "Active" solar components—in the form of small fans—draw off excess warmed air from the greenhouse. The air is directed

through ducts over 2-ft-deep rock beds (1165 cu ft, storing 20,000 Btu per degree F) placed under the tiles and floor slab of the living room and dining room. The distribution figures for the mass wall average 1575 Btu per hr per degree F; for rock bins, 792 Btu per hr per degree F.

The greenhouse/wall concept not only counters disadvantages of direct-gain solar heating—glare and fading of fabrics—but because of the cold Santa Fe winters, makes a very marketable addition.

The Balcomb greenhouse averages about 50 degrees higher than the outside, and the temperature in the house rarely varies from 70 F. While the south (greenhouse) mass wall needs an R-factor of only about 2, the Nicholses found that the R-factor on east, west, and north walls had to be raised to 33 because of the location. Thus they built walls with 2" x 8" studs rather than the normal 2" x 6", and sank the perimeter walls into the ground several feet to take advantage of the earth's insulative properties.

First Village



Insulation materials include 7½-in. blown-in wood-fiber insulation, and six-mil polyvinyl vapor barrier on walls under plaster. Windows naturally have weather stripping, storm panels, and some are shuttered, while the greenhouse employs double glazing. In the summer when the temperature rarely exceeds 80 F, fans are turned off and vents opened, including one at the top of the stair. Natural convection draws hot air out of the house; in addition, night air can be circulated over rock beds for daytime cooling.

Owing to the nature of Douglas Balcomb's work, the house is being heavily monitored by small computers at 15-minute intervals. According to the winter average, these houses take about 1160 Btu per sq ft a day from the sun, with a

solar fraction—the percentage of heat supplied by the sun—of about 90 to 95 percent in this one. Thus the Balcombs find the cost of heating the 2400-sq-ft house (no heat is required before November 15) comes to about \$15 a month for the electric backup heating.



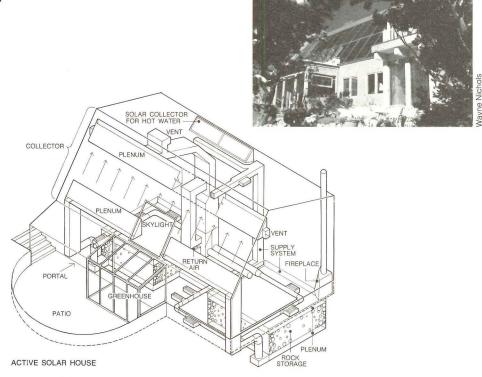
McDowell House (Unit 2)

This active solar house, built at the same time as the first passive solar residence, provided a good comparative model for testing the advantages of one method of solar heating over another. The Nicholses installed 365 sq ft of solar collectors with an aluminum modular finned configuration on the roof over 3½-in. fiberglass insulation. A forced-air system distributes heat (400,000 Btu per day generated) through the house. Excess heat—up to 1 million Btu—can be stored in rock bins of 1150 cu ft, 3–4 in. deep, with backup heating provided by an electric duct heater in the air handling units.

Passive solar methods supplement the active one: a south-facing greenhouse with 125 sq ft of glass can heat the house during the day, so that the heat from collectors may be stored for night use. In addition, the master bedroom receives heat through direct gain—96 sq ft of windows—which is stored in the flagstone floors and concrete walls.

In warm weather, vents in the sides of the house and middle of the roof are opened individually to permit the collector to vent and the fan to pull the cool air through the windows on the shady side of the house. The fan also pulls air through the rocks at night.

Despite the fact that the 2200-sq-ft house is sunk several feet below grade and most windows are double-glazed, the electric heating bill averages \$50 a month. The higher than normal bill is due partially to the lower R-factor (27) of the 2" x 6" stud walls. More to the point, of course, is the cost of power needed to operate the forced-air system—a main reason the Nicholses have been pursuing passive solar heating methods.





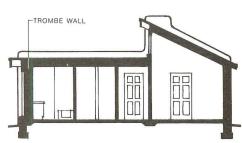
The Hamilton House (Unit 3)

The third house uses the Trombe wall (see p. 106) in combination with the greenhouse and direct-gain windows for its passive solar heating. The Trombe walls themselves are not the convective type, that is, vented at top and bottom to allow air to circulate throughout the living space. To avoid construction problems, need for backdraft dampers, and problems with spider webs, etc., the Nicholses specified a "stagnated" Trombe wall. Thus, 82 sq ft of glazing pierces the 285-sq-ft walls of 16-in. cellular adobe filled with concrete, allowing natural light and direct-gain heat into the living areas.

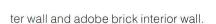
While a slight decrease in efficiency results with the Trombe wall (since only about 50 percent of the insolation hitting it is absorbed, or 506 Btu per hour) other factors compensate: the solar radiation is stored in the thermal mass of the concrete wall and brick floor, and then is radiated out with a lag of five to six hours, while the heat stored in the Trombe wall is radiated with a lag of eleven to twelve hours. Thus the house receives heat throughout the 24-hour cycle.

In addition, the greenhouse's 96 sq ft of glazing directs sun to 10-in.-thick adobe walls, totaling 271 cu ft, which release heat gradually to living spaces and the greenhouse. The clerestories, 97 sq ft of glass, provide direct-gain heating into the back parts of the house where heat is absorbed by the 8-in.-thick concrete perime-









To prevent loss of heat at night, the clerestories and windows in the Trombe wall will be shuttered. Overhangs shield the Trombe wall, the direct-gain windows, the greenhouse and clerestory windows from the sun's high angles in the summer to prevent overheating. Natural ventilation and radiation to the night sky through windows and doors should keep the mass of the house cool.

While it is difficult to definitively predict



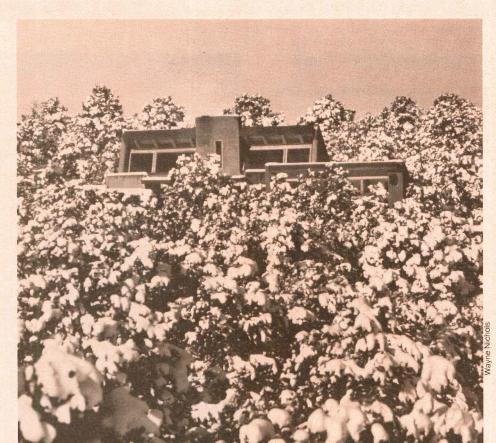
FLOOR PLAN

the electrical bills for backup heating until the house has been occupied for several months, the solar fraction ranges from 80 to 90 percent for the 1800-sq-ft house. The Nicholses see this design in particular as prototypical for other "tract" houses. They also installed a "skylight water heater" designed by Steven Baer, where an 80-gallon water tank hangs suspended from a skylight with a curved exterior reflector. Generally, water heaters in the village operate by detached solar collectors.

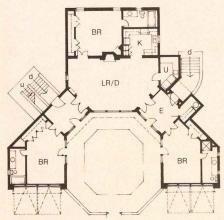
The Gunderson House (Unit 4)

The Gunderson House experiments with another component for passive solar heating—the water-filled Trombe wall. Eight precast modular sections of the concrete water wall were installed along the south side of bedroom wings. While this feature costs about \$10 a sq ft, it is less expensive than the \$18 to \$25 a sq ft typical of "active" solar collectors. To defray the initial extra cost, designers for the house, architect William Lumpkin, engineer Buck Rogers, and Susan Nichols obtained a grant from HUD in the second cycle of the National Solar Demonstration Program.

The space between the Trombe wall exterior, painted black, and the double glazing that sheathes it can go as high as 190 degrees on a sunny January day. This heat conducts through the 2-in. layer of concrete to a 6-in.-thick area of water held in a



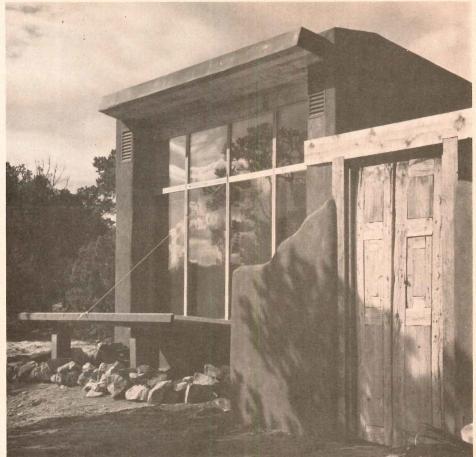
First Village



FLOOR PLAN



plastic bag. The 77 cu ft of water stores the heat (4620 Btu per degree F), then radiates it through the other side of the concrete wall (which totals 132 cu ft with a heat capacity of 3960 Btu per degree F) to interior spaces at night. Mass walls and floors inside provide another 546 cu ft of storage for heat. Meanwhile, the living room and third bedroom are heated through direct gain, accomplished through



275 sq ft of glazing in windows and clerestories. Overhangs cut gain in summer.

To increase the performance of the water wall by 50 percent, the designers installed 8' x 16' shutter reflectors that in turn keep heat from escaping by night. Again the north wall is sunk into the hill to cut heat losses, and entry rooms or greenhouses serve as thermal air locks, with backup heating provided by electrical

baseboard units in key areas.

The Nicholses have found that the electric bill for the house averages \$40 a month during the winter, higher for the 2200 sq ft than ideal. The water-wall rooms perform quite well, but the living room and third bedroom remain rather cold with just passive solar heating. The solar fraction comes to about 70 percent in contrast to the 90 percent of other houses.

The Schmidt House

This 1650-sq-ft house, designed and built for a particular client, uses two passive solar heating components—Trombe wall sections pierced with direct-gain windows along the south facing façade plus clerestories admitting solar heat into bedrooms at the back of the house. The 6000-lb Trombe wall is 16-in.-thick poured concrete, faced with 260 sq ft of double glazing. Again the convective type of Trombe wall was not used, with an acknowledged loss of efficiency, so that 100 sq ft of large. direct-gain double-glazed windows could admit light and heat to the living space. Brick-paved floors provide the thermal mass for storage, supplementing the heat being radiated from the thick Trombe wall sections.

Clerestory windows, 150 sq ft, also direct the sun's heat onto 8-in. adobe interior walls and an 8-in.-thick concrete rear wall.

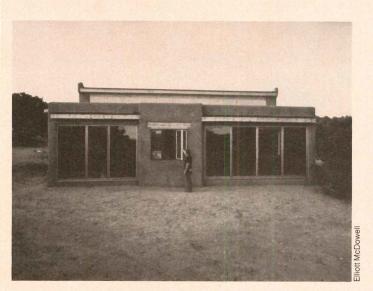




FLOOR PLAN

To cut down loss of heat, the house was sunk into the ground several feet and its south-facing glass and clerestories fitted with custom canvas or fiberglass shutters. While the Schmidts have the usual backup electric heating system, they find the temperature in the house rarely falls below 50 F. The electric bill for heating in the winter averages \$20 a month.







SIII Mat

The Norquist House

The Norquist House was designed for a specific client, a young single person who didn't want to pay more than \$50,000 for a house. The Nicholses gladly accepted the challenge since this was the type of residence they hoped could provide a prototype for the La Vereda project (p. 110). In spite of the compactness of the floor area—1100 sq ft—the house succeeds in

being architecturally one of their most interesting: the height of the living room ceiling, the pitch of the roof, and the clerestory glazing vary the interior spatially.

While the plan is oriented so that kitchen and dining room face south, the living room receives sunlight from 88-sq-ft clerestory windows. Other clerestories introduce light and heat into a study and sleeping loft. Like the Schmidt house, the south-facing wall is a 16-in. concrete

Trombe wall, 218 cu ft, covered with tempered double glazing and pierced with 38 sq ft of direct-gain glazing. The north mass wall is 8-in. block with 2" x 6" stud wall or 6-in. wall of cast concrete; other interior walls are composed of 2" x 4" and 2" x 6" stud frame. Because of the compact size and efficiency of the spaces, the passive solar heating components and the fireplace work quite well. In fact the owner rarely turns on the electric heating.

The Ogg House



FLOOR PLAN

Only just occupied, the 2200-sq-ft Ogg House uses a 240-cu-ft Trombe wall pierced by 50 sq ft of direct-gain glazing along the front part of the house. Clerestory windows, 54 sq ft in the living room, direct the sun's light onto a concrete mass wall which is combined with a fireplace and banco seating. However, since the clients preferred the sculptural wall, designed by Robert Peters, to remain open above eye level, a good part of the heat

storage capacity is lost. A greenhouse with 128 sq ft of glazing supplements the other passive solar heating methods, and the northeast and west exterior walls are made of 2" \times 8" studs with 7½-in. fiberglass for high insulative capacity.

Summer heat gain will be controlled through the use of overhangs and vents in the clerestories, plus operable vents along the bottom of the Trombe wall's direct-gain windows.

Introduction Part II Formal dynamics

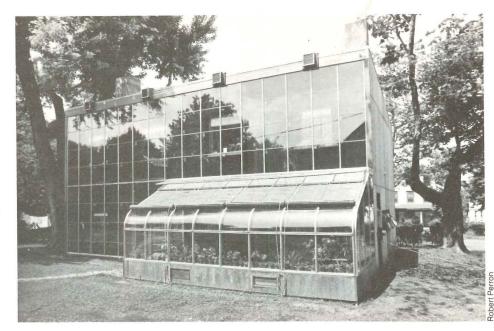
In the current period of questioning of architectural values and directions, the implications of energy use on form must be confronted sooner or later.

Go ahead and say it. You think it's boring. Boring to have to learn about the Btus of Trombe walls, the R-factors of earth berms or the efficiency of evacuate tube vs. flat-plate collectors. Boring to be told to start designing buildings or planning urban developments with yet a whole new set of constraints. And not exhilarating to have to worry about creating new forms in response to new methods of heating, ventilating, and air conditioning.

Of course, we would like to remind you, needlessly, of the old adage: whoever is in the right place at the right time doing the right thing either makes money or makes history—and sometimes both. If energy supplies and methods change the way we live and build as drastically as they might, what was formerly the domain of the HVAC specialists will drastically affect your architecture and the way it looks, like it or not. At that point, pressure for change, from public and private clients, may catch you unprepared.

The above statements apply to only some of you, of course. Others of you will question this concern over formal issues and form-conscious architects. You might think such dire warnings unnecessary and discussions of architecture for art's sake irrelevant. Beauty, you assure us, will evolve naturally from energy-conscious design. Ethics—i.e., solving the problem with an energy-conserving solution—carries its own aesthetics.

Both types of extremists in this argument, could be doomed to repeat history: one group, purely formal in orientation, losing a recently strengthened position to those who seek to respond to outside stimuli such as energy needs. The other,



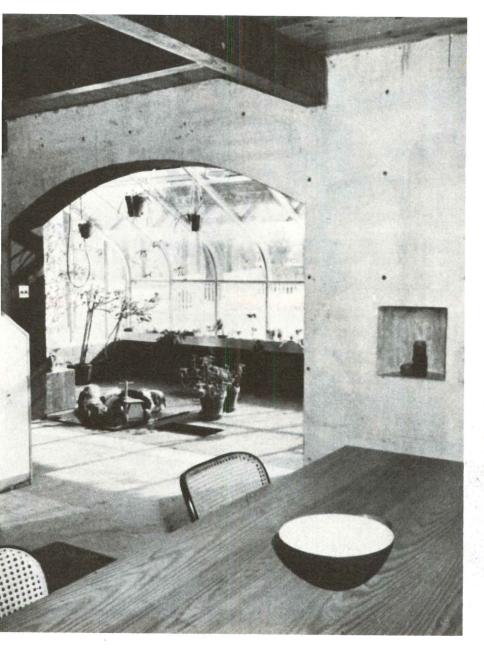
who regards formal aspects of architecture at best superfluous, at worst frivolous, may take too much for granted about architecture's public appeal. As shown by Modern Architecture's example, beauty does not always grow out of functional and technical solutions; it has proved to be more elusive. Because Modern Architecture fell short of its *promises*, doubts were cast about its very *premises*.

The current situation bears some resemblance to the one that directed the course of early Modern Architecture, yet major differences do set them apart. In the 19th Century the emerging technology of material and structures provided the stimulus for the generation of new forms. The 19th Century's impact was heightened by the fact that new methods of construction formed an integral part of a whole revolution in industrial production and capitalistic expansion. This context, however obvious, still influences markedly any basis of comparison.

Differences and divergences

With regard to the present-day economic and technical forces that determine the creation of architectural form, it is still too early to tell exactly what impact energyconserving measures and the shift toward renewable fuel sources will have on the post-industrial era. In a very specific sense, the immediate change in the use of energy, or building fuel, means the influence on architectural form begins on a level less direct, less visible, and less physical in nature than change in type of technology or building blocks. Where, however, structure and materials do act as energy suppliers and conservators, form is obviously very directly affected.

The basic difference between current and early Modern situations, architecturally, concerns the grammar of the form and how it generates its own language: steel or concrete allowed spans, cantilevers, and curtain walls—providing not only a new vocabulary but a new syntax of architec-







Douglas Kelbaugh built an 1800-sq-ft passive solar home in Princeton in which the two-story house obtains its heat by virtue of a Trombe wall and a smaller greenhouse along the south face. The treatment of the 15-in-thick Trombe wall can recall Corbusier's Maison Jaoul, while allowing the thermosiphoning effect to take place.

tural form. In the present-day instance, the vocabulary sometimes reverts to, say, heavy masonry or thick stud walls of the pre-Modern era. Yet the extensive use of glazing in passive solar heated buildings, for example, suggests the glass curtain wall of Modern Architecture still has a place—just a slightly different one. The vocabulary, an amalgam of mostly familiar pieces, carries new meanings, but does not necessarily imply a different syntax. Because of these factors, a cohesive language of form has yet to arise, and in fact may not for some time.

In the meantime, a schism between energy-conscious architects and form-conscious ones could widen. Granted it eventually may prove to be part of a dialectic that resolves itself in the synthesis of a new architecture. Right now the bifurcation of effort results in a lot of awkward energy-saving buildings dotting the landscape, and a lot of well-designed buildings performing inefficiently and uneconomically.

False polarities

To talk as if there are only two groups of architects involved in these issues undeservedly places much of current architectural effort at two ends of the spectrum. Yet the spectrum ranges from the practical nuts-and-bolts experimenters such as Steve Baer in Albuquerque, who invent new methods and techniques, to large architectural firms like C.F. Murphy and CRS, who come at low-energy architecture with a high-tech image. In fact, some of their work in the past has suffered problems with regard to energy, but that was yesterday, or so it seems.

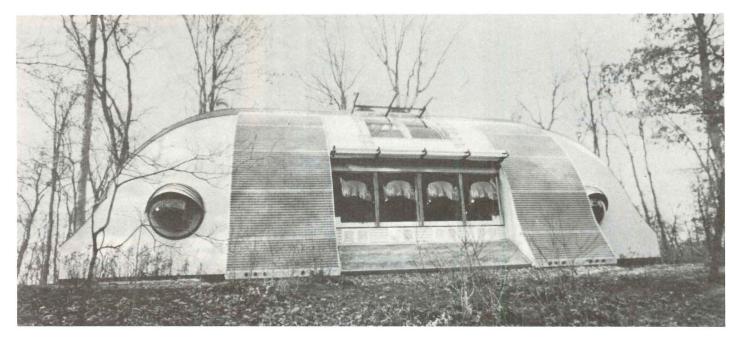
Then there are architects like Richard Crowther or Richard Stein who have been advocating a more comprehensive approach with a total view to energy conservation, materials and resources limitations, etc. Still others bring a holistic perspective of a poetic sort to their work. Theoretically minded architects like Emilio Ambasz (p. 142) explore philosophical implications of

connecting architectural form to nature and bringing energy-conscious design in line with social rituals and acts.

In this spectrum belong, too, the inbetweens, the architects who install the hardware like putting on a new hat, with little regard to the overall patterns of energy use. The most distressing of these practitioners are those who indulge in "energy expressionism" in the misguided belief that they are responding to issues of form. Large-scale buildings using energy savings as a rationale for aggressively contrived schemes abound. Behemoths that look like oversized typewriters so that the roofs can proudly display their solar collectors (where the keyboard should be) or earth berms capped in concrete (much like a typewriter base) could give energyconscious architecture a bad name. The manipulation of form to become a sign of energy savings too often becomes gratuitous—not justifiable in technical terms, and certainly not in aesthetic ones.

Total Environmental Action designed and built the spec house (right, top) as a HUD Demonstration experiment in Harrisville, NH. The 1585-sq-ft house maintains a New England vernacular architecture combined with solar collectors on the roof. A galvanized steel sheet house (right, bottom), 2400 sq ft, was designed and built by Michael and Ellen Jantzen in Carlyle, II. Anthropomorphic in look, the house's curved plates hold solar collectors for heating; bubble windows to admit sun. With the project (opposite, top) for the 215,000-sq-ft DOE and Argonne National Laboratories, Chicago branch, C. F. Murphy Associates designed a circular building with solar collectors, light monitors, and cooling pond on the roof. Holabird & Root (opposite, bottom) installed a solar collector system for Monsanto Co.'s Environmental Health Laboratory in St. Louis. Energy from the solar collectors will heat one-third of the hot water needed in the 47,000-sq-ft laboratory.





In this group let's also put architects who boast about their high-rises using less energy than a 1960s structure, when the high-rise is clearly out of place, say in a low-scale, nonurban context. These architects may go to great lengths to make windows small, and clad the frames in limestone or granite, but they are being disingenuous. Again energy is being turned into a religion to which all sorts of sinners pay lip service.

What next

To avert the dangers of energy-conscious components and devices being crudely grafted onto architectural form—the Frankenstein effect—in the name of science, the profession needs to involve itself in formal issues soon. Government encouragement does help. Both HUD and DOE have been trying to reach the building industry through their program of grants and funding, and have encouraged efforts from a grass-roots level. But, as

Princeton architect Douglas Kelbaugh argues, funds could be directed more specifically to architects experimenting *formally* with energy-conscious architecture.

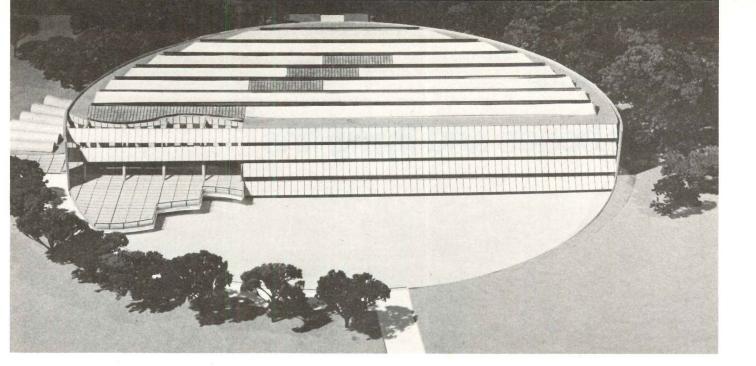
"It might seem as if the government is catering to an elite of the profession," reminds Kelbaugh, "but generally the developers take their lead from local building practices and local style, and workaday architects take their lead from more inspired architects, who take their lead from the most theoretical architects."

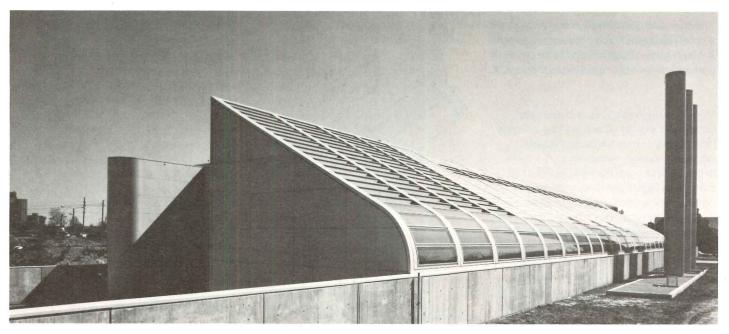
Similarly, efforts have been made by certain institutions to merge the findings of energy experts with "high-design" interests. Last summer, for example, Harvard's Graduate School of Design held a seminar on energy-conscious architecture, sponsored by the AIA Research Corporation. The school enlisted Stanley Tigerman and Robert Stern for the studios, two architects heretofore better known for their polemical work in Post-Modern Architecture than for passive solar design. Both Tigerman and

Stern felt the "arranged" meeting of separate interests proved to be quite fruitful.

In contradistinction to the energy profligacy endemic to Modern Architecture, we are now in the "post-profligate" era, as Stern puts it. Stern is not sure, however, if current energy-conscious methods and hardware can generate architectural form in the same way 19th-Century developments gave rise to Modern Architecture. Instead he gives more credence to basic natural principles of ventilation, heating, and cooling and means to obtain them that could be rediscovered and integrated into current formal design efforts.

One can see here a connection between older building forms and techniques and the "Post-Modern" leanings toward historicist and vernacular design that depend on traditional means of heating, lighting and air conditioning. Furthermore, the growing "Post-Modern" emphasis on dividing open spaces into rooms with distinct purposes and spatial character, into





separating these spaces by volumetric masses instead of planes, in making walls textured (through ornament), and in designing the landscape as a natural but architectonic counterpoint to building draws not only on earlier architectural work, but parallels approximately a number of energy-conservation measures. The inclusion of traditional architectural elements such as fireplaces with inglenooks, greenhouses, and clerestories in energy-conscious design can create special places and dramatic spaces formal-minded architects seek while serving the building's pragmatic operations.

The young not-quite-established generation of architects, like Kelbaugh, Dan Scully of Total Environmental Action in New Hampshire, Harrison Fraker in Princeton, Peter Calthorpe of San Francisco, Dan Prowler in Philadelphia, and David Sellers in Vermont, are collectively and individually trying to bridge the gap. Still it is a long way before anyone is about to claim that a

Muthesius, Behrens, or Gropius has arrived, or that a Werkbund or Bauhaus is emerging to develop new architectural precepts dealing with energy and form.

On these pages are shown efforts by various practitioners at combining art and technology. The house, as befits its traditional role in postulative and experimental design, figures prominently in energyconscious design. For that very reason, and because so much has been published on "solar" houses, buildings from nonresidential categories were deliberately selected for the pages that follow. They were chosen with an eye to the use of innovative energy-conserving measures, such as the roof design of the Mary Medina building in Taos (p. 128), or the Pitkin County Airport in Aspen (p. 120). They are also selected for their straightforward approach to formal questions. If they don't go too far into the realm of high art, at least they don't revert to gratuitous form of "energy expressionism."

Form follows energy?

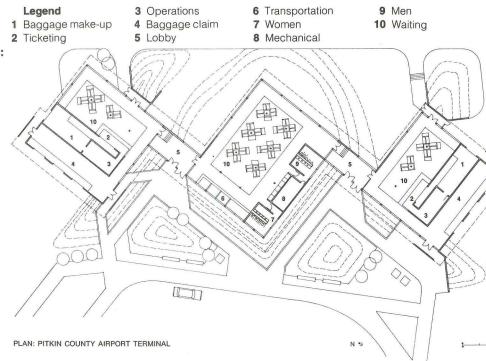
Still left unanswered is the question about the extent to which changes in energy use will affect form. Because of the various reasons cited above, it would seem unlikely that a radically different form will emerge as a result of new energy uses. Buildings will look different, they will be oriented differently, and constructed differently. Solar collectors and Trombe walls are visible physical elements that influence the shape buildings take. But they do not necessarily prescribe a total aesthetic composition or supply the "DNA"—the basic genetic code, so to speak—of a new architectural form. Since we no longer believe that beautiful form is the natural byproduct of function—or good intentions—a formal approach that can allow for these changes will still be needed. And while so doing, perhaps it will also manipulate these elements, thereby absorbing and transforming them into a new architecture. [Suzanne Stephens]

Sweet beads and flying fins

The client had a unique program and site: a small efficient Rocky Mountain airport. A clean plan organization for circulation and a passive solar section is the result.

Pitkin County Airport is a nice place to come from the sky. The plane never really lands in the normal sense of the word. Aspen is too high. Airplanes come there to perch. There are no night flights, only thirty or so flights per day, and just two commercial airlines. And there are no snoring business types on those flights. Planes are filled with healthy bodies keen to share Aspen's mountains, cultural events, snow, and air (probably the only airport in the world worth coming to just for the air). In winter, the baggage sections of the planes are filled with skis; the clothing is brightly colored and warm. Faces are radiant with expectation. The normal task of this particular airport, therefore—get me to the slopes on time! The client then added "Design us an energy-efficient building."

Planning for the landing: Functionally, for deplaning, all that is desired between the airplane and the waiting ground transportation is a gateway with a baggage pickup. For enplaning, an added function is a place to purchase a ticket and wait. Lining up the planes on one side and the ground transport on the other, the building form quickly becomes linear. Like the planes, the building too must meet the ground. A change in site elevation from one end of the linear plan to the other means stepping the floors. The energy constraints mean rotating the resulting built segments (or pods, as the architects call them), aiming them to greet the sun, and berming them on two sides to help control heat loss. The added dominant building requirement was to melt into the spectacular landscape with as little notice as possible while providing ample mountain views from within. Other corollaries from the climate included flat



Pitkin air terminal orders traffic in plan (above) and concedes visual focus to the site (below)





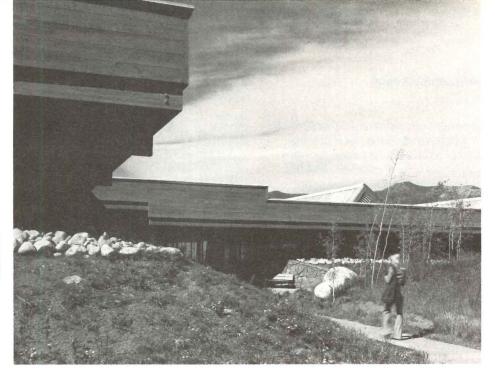
The building expresses dutiful reverence to the glorious natural surroundings upon entry from the ground (at right) and from the air (above). On the interior, the Glu-Lam beams, plants, and seating clusters suggest a domestic scale. Beadwall and Skylids control light and heat.

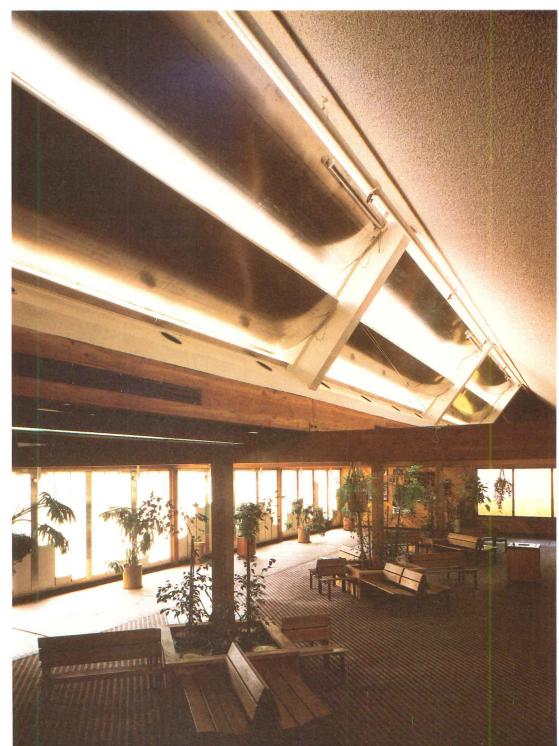
roofs to gather snow for its insulating and reflective qualities, a low profile to the wind, and dish-shaped berming to collect snow and reflect light and heat into the windows.

Three pods: All of the pods have certain features in common. A south-facing wall of each is double glazed and fitted with "Beadwall." East- and west-facing walls are double glazed for view and light (and shaded by overhangs for summer). The floor slabs are thickened for added thermal mass near the Beadwall. The walls are concrete masonry grouted to add to the mass and oriented to receive direct gain through the skylights. All of the spaces receive a pair of sawtooth skylights fitted with "Skylids" for gaining both light and the sun's heat.

Sweet beads: Two innovations in energy design are utilized at the Aspen airport which promise to add to our energy/ architectural vocabulary. The first is Beadwall. Beadwall is a system of construction which blows expanded polystyrene pellets into the sealed space between two glazed surfaces. (The beads are treated against static cling.) The same pellets are sucked out of the space when the direct sun is desired. A product invented by Zomeworks, the purpose is first to allow the heat to come in, then keep it in on winter days, and keep the heat out on summer days. Storage containers for the beads are needed as well as reversible vacuum pumps and pipes to push and pull the pellets. At the Aspen airport, the system is manually controlled. A photocell and thermostat can accomplish the same thing mechanically.

Flying sunfins: Another innovation from Zomeworks is "Skylids." The fact that they are very large, insulated aluminum shutters is not so new. The method by which they open and close automatically is ingenious. Attached to each side of the louver is a small container of freon. A cop-





Pitkin County Airport

per pipe connects the two containers. The sun's heat transfers the freon from the canister on one side of the louver to the other. The weight of the freon shifts the balance and swings the louver open. Without the sun, the cycle reverses and the louvers swing shut, retaining interior heat. In summer, the louvers can be tied closed to reduce thermal gain.

Lights and sights: In summer months when the south walls are filled with beads and the louvers can be closed, the west and east-facing windows still provide natural light and view. The lighting can be artificially modulated by fluorescent, incandescent, or reflected light from lamps trained on the closed Skylids.

The fluorescent light fixtures are mounted directly below the ducts of the mechanical backup system running partially exposed above the waiting spaces. Heat that rises from the lights transfers to the duct. The auxiliary heating system is available about six months out of the year and turned off for the other six. In the summer, the outside air is drawn into the building to cool the thermal mass, and the temperature is controlled with Beadwall.

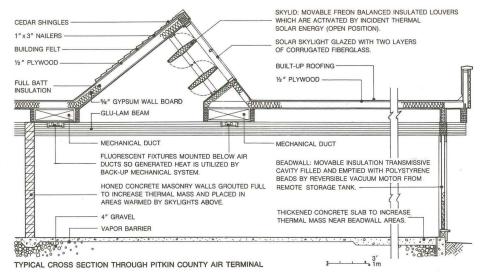
In addition to the thermodynamic properties directly inherent in the use of the Skylids, their use also permits the other flat ceilings in the space to be lower and reduces the volume while maintaining the acoustical sensation of a larger space. The Skylids' obvious visual connotations of airplane geometries allow them to lend particular formal expression to the space at no expense to their efficiency.

How does it all perform?

Arrivals: Landing at Aspen airport is a spectacular experience in winter. The snow and mountains are so bright and dazzling that if anything else fills your eye between the plane and the airport terminal it is probably a tear. The path from the airstrip to the taxi line is a straight and efficient shot culminated on the taxi side with a circular hole to both punctuate the termination of the flight and signal the beginning of the vacation.

Departure: The departure process is less direct. The deplaning exits are partially shielded from view, but two equally visible entries are unnecessary for such a small building. Each entry is an airlock, but since stairs separate the pods, the only barrier-free method of entering the building is through the deplaning exits. Admittedly the building is not big enough to make a possible miscue in circulation a big issue.

The space within the pods is remarkably domestic in scale. The laminated-wood beams and wood trim take the sting out of the naked, low-budget block walls. These



Many of the energy innovations at Pitkin Air Terminal occur in cross section. A snow laden flat roof reflects light and heat into the skylight. The Skylids open automatically when exposed to sun. They seal tight at night to preserve the solar gain in winter, and can be tied shut in summer. Grouted masonry walls and concrete floor help to store heat by direct gain.

walls and spots of bare concrete floor remind us that the building has been intentionally designed for temperatures which accommodate heavier winter clothing.

A passive record: The Aspen airport claims the indoor record for being the largest passively heated structure in America. But, in the words of Architect Larry Yaw, "A passive building is only as effective as the people who learn to use it."

The Beadwall and Skylids can do their job well, but employees forget to control them. The architect's choice to make the Beadwall manually controlled might have been accompanied by the choice of using clear glazing for the Beadwall system. Had clear glass been used, the choice of view or no view might have prompted more diligence on the part of the people responsible for the controls. The Beadwall has undeniable aesthetic qualities. The visual reference to snow adds continuity, and its presence, active or inactive, is a source of passenger fascination.

As brightly lit as the spaces were, most of the fluorescent lights blazed on. The Skylids adjacent to them are so bright, it was hardly possible to tell that the lights were on. Another energy leak was an entry door into the major lounge area which had been wedged open, destroying the airlock's effect. Elsewhere, one redundant set of Skylids is tied shut over the snack bar on the east side of the center pod (allegedly because of the excessive heat gain).

In conclusion: The architects of Aspen airport have attempted a courageous transition. In translating residential-scale passive technology to a transportation terminal they have tested the timeworn tenets of indifference which usually accompany operating such facilities. If their test fails, their building is in for a beating. If it succeeds, both the passengers and the new technology will have found a new home. [Richard Rush]

Data

Project: Pitkin County Airport Terminal **Architect:** Copland Finholm Hagman Yaw Ltd., Aspen, Co, Larry Yaw and Jim Copland, project design; Bill Campbell, project manager.

Program: conceived for initial use as an air transportation facility, the building was designed to accommodate a comprehensive transportation center for air, auto, and ground transportation systems serving Aspen and related population centers. The owner wanted a low-cost, functional, public building that architecturally related to its natural surrounds and demonstrated the economical use of solar heating and thermal design. The building is subjected to seasonal use variations which accompany a tourist-related destination. 17,000 sq ft **Site:** a flat portion of a narrow mountain valley in high Colorado Rocky Mountains (8000-ft altitude). Actual building site characterized by

Structure: post and beam (glue-laminated wood members) with prefab joist panel roof structure.

high plateau sage brush cover rising to high

mountain peaks beyond.

Major materials: glue-laminated Douglas fir, cedar siding, concrete masonry, gypsum board with acoustic surface, reinforced concrete, Skylids, Beadwall.

Mechanical system: passive solar heating (± 45 percent space heating), gas-fired hot water piped to air-handling units to deliver hot air (± 55 percent space heating), air-handling units equipped with economy cycle (100 percent outside air) for cooling when needed. Each air-handling unit is controlled by dead-band thermostat.

Consultants: Design Workshop, land-use planning; Anderson & Hastings, structural; McFall & Konkel, mechanical; Sol Flax & Associates, electrical; Zomeworks, solar.

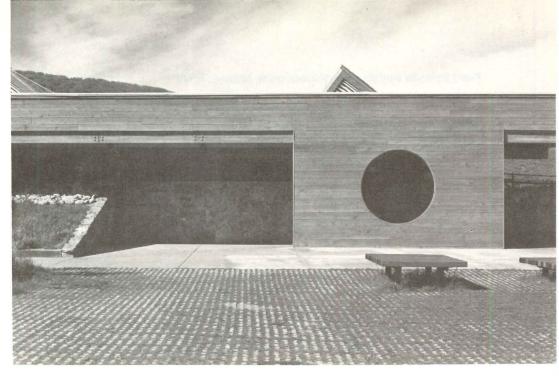
General contractor: Greer Construction. **Client:** Pitkin County Board of Commissioners.

Costs: \$550,000 (\$32 per sq ft), construction; \$28,000 (\$1.64 per sq ft), solar.

Photography: Courtesy of the architects except where noted.



A circular hole dramatically captures a view of Aspen upon leaving the terminal. Its presence punctuates the exit experience and acts as a screen from arriving passengers.





The bottom side of auxiliary ductwork is left exposed at Pitkin. Fluorescent light fixtures are mounted to recover rising heat from lights. Diffusers occur at midspan in adjacent beams.

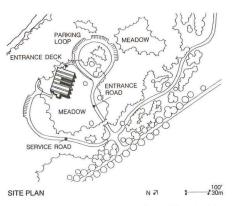






The solar underground

A bermed and buried plant lab and administration building extends out of the earth only to collect the sun's rays.



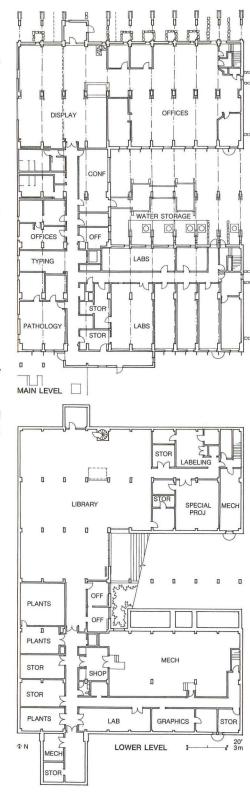
In 1971, the Mary Flagler Cary Charitable Trust donated 2000 acres of land in the Upstate New York Hudson Valley town of Millbrook to the New York Botanical Garden. Thus was established the Cary Arboretum, which is an educational and research institution dedicated to increasing knowledge of the plant world. In addition to the land, however, the Trust also gave most of the funds for the development of the arboretum's facilities and programs. These were initially scattered in some old buildings on the site, which the staff still uses, but it soon became apparent that a major facility was needed for centralizing the administrative and research activities.

The arboretum staff shared its benefactor's concern for conservation of natural resources, which is one of the Trust's major goals, and thus sought professionals who would also be sensitive to such interests. But that was in 1972, and in those innocent days before the energy crisis and the Mideast oil embargo, few designers (or clients) were overly concerned with ecological problems. Some were, though, and it was two pioneers in the field of environmental enlightenment that the staff finally chose. They were ar-

chitect Malcolm Wells and engineer Fred Dubin, who were later joined by the arbore-tum's Capital Projects Manager Daniel Brown in carrying out the design and construction of what was—and still is—one of the most environmentally sensitive and energy-conscious structures to be found.

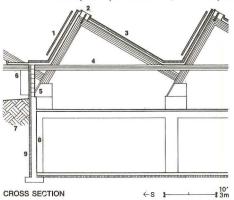
The Plant Science Building, as the administrative and research center is called, "was conceived from the beginning as a holistic structure," Fred Dubin recalls, and explains that "probably no other building existing integrates all of the aspects of environment, ecology, and engineering that this one does." But what, specifically, are the special attributes of the Plant Science Building? As with any ecologically advanced structure, they begin with a very careful consideration of the site, of its topography and plant life, and of the way a structure can be placed upon the land both to take maximum advantage of its natural characteristics and to minimize any deleterious effects on the terrain. With these considerations in mind, the twostory, 28,000-sq-ft concrete, timber-roofed structure has been placed in the northwest corner of a small clearing where it is nestled against a dense hemlock forest, and where it is also protected by a small range of hills, both of which shelter the structure from winter winds. In addition, the building has been sunk two-thirds into the ground to be further insulated from the elements.

Although the 1-ft-thick masonry block and concrete structure provides great thermal mass in itself, the walls and roof of the entire structure have been wrapped, on the outside, with thick layers of insulation. In the winter, this allows the structure to act as a heat trap by absorbing heat from the heating system during the daytime, and returning it to the interior of the building at night. Where the coldest sides of the building—those facing north, east, and west—are exposed above ground, their walls are protected by earth berms,





To monitor solar panel performance, both flat-plate-selective-surface and tubular-reflectorized concentrator types are integrated into one system.

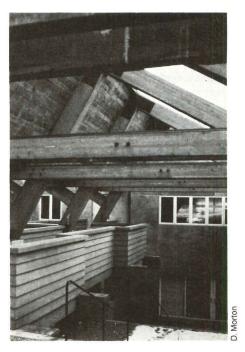


1 Solar collector. 2 Roto-panels insulate skylights at night. 3 White shingles reflect light to collectors. 4 Timber structure = renewable resource. 5 Small windows are double-glazed and have sliding insulation panels for winter night protection. 6 Overhang and sunfins prevent summer sun from entering building. 7 Deep mulch on soil requires no irrigation. 8 Block concrete and masonry for great thermal mass.

9 Insulation occurs outside the structure.



A sunken courtyard (above, below left) is at east side of building, entry (below) is at north.





Plant Science Building

which thus brings about three-quarters of the entire structure into contact with the earth. On those sides, window openings are small. On the southern exposures they are large, to admit light and warmth in the winter, but they are also protected with sunfins and overhangs to reduce solar radiation in the summer. All of the windows are double-glazed, fully weather-stripped, and equipped with sliding interior insulating panels. These units can be closed on winter nights to prevent heat from escaping through the glass, and they can also be used during the summer daytime to help keep heat out of the building. If they are used during the daytime, natural light is brought into the building through a system of long, north-oriented skylights that also have insulating panels, but in this case they are rotating ones. In addition to these insulating devices, all of the building's exterior structural joints have been tightly sealed.

When the skylight panels are open, light washes down the interior walls and flows throughout the largely open-plan space by means of light wells between the two floors and through a system of borrowed light at the upper level. In general, spaces not requiring natural daylight, such as the laboratories, have been placed at the lower level. But the library is also there. It receives natural light from one of the monitors and also from its large glass doors that face into a protected, sunken courtyard on the east side of the building.

By far the most striking feature of the Plant Science Building, and about the only thing one sees on approaching it, is its long, sawtooth roof that houses the skylights in its peaks, and also the solar collectors that provide all of the domestic hot water and virtually all of the heat for the building. Each of the seven rows of southfacing collectors is 110 ft long and 7 or 8 ft high, and each is inclined 60 degrees to best absorb energy from the winter sun. Inside the 5650 sq ft of flat, black, glasscovered collectors, a mixture of water and antifreeze is circulated and heated before a heat exchanger transfers the heat to water that is stored in two insulated concrete tanks that have a total capacity of 15,000 gallons. The hot water enters heating coils from the tanks, where fans blow air over it that is circulated through the ducts. Because the hot water can be collected and used at the low temperature of 105 F, 85 percent of it can be used without assistance from a heat pump. Also, because of this low-temperature feature, hot water can be collected during more hours of the day, which is especially important during the winter when the sun is low and the sky is often overcast.

At times when the collectors cannot provide enough heat, a refrigeration unit (that can be used as both a heat pump in winter and a chiller in summer) can provide back-up heat (or cooling). In the winter, this works by "pumping" heat either from solar water that is less than 105 F, or from well water that stores in the ground at 49 F. In the summer, the same refrigeration unit can be used as a true chiller on very hot days to lower the well-water temperature to 42 F before it enters the fan-coil units. On more moderate days, the well water can be used in the fan coils directly, without assistance from the chiller, at its normal temperature. Processed warm water from the cooling system is returned to the ground, where it is filtered through layers of gravel and cooled, before reentering the aquifer for reuse. At the end of the summer day, all of the air is flushed out of the building and replaced by cool night air to conserve use of the cooling system. In the winter, heat from warm exhaust air of the fume hoods in the laboratories is captured by heat-recovery coils and reused with heat exchangers to preheat incoming make-up air.

All of the environmental systems in the building are interconnected through a computerized control system that automatically selects as many as twelve various modes of operation. These can range from use of solar-heated water from either one or two tanks to solar energy combined with heat from the chiller. Or the system can select waste heat from the generator, or call for a number of various modes of cooling. Whatever the combination is, however, the selection is always based on the order of priority of minimum energy consumption. In addition to this function of the control system, the computer also monitors the building over time and stores that information in its memory. This will allow the building to be analyzed over any selected time period to learn specifically where and how it is functioning most efficiently, and why.

This much is known so far. The building was designed for a heating load of onethird to one-fifth of that for a conventional building of the same size. This translates into 43,000 Btu per sq ft per year as compared to 150,000 to 300,000 required for a conventional building. In real dollars and cents, that figure translates another way according to the arboretum's Capital Projects Manager Daniel Brown. He says that after a year's operation, during a time when some of the kinks were still being worked out, the building's combined heating, cooling, and lighting bill has run at 43¢ per sq ft per year. That may not mean much if you don't know that the average cost is more than three times that amount, or about \$1.50 per sq ft per year.

If all this sounds very rosy, there is

nevertheless one very serious problem with the Plant Science Building. This is not so much a problem with the building, however, as it is with the people in it. They are all, by profession or by inclination, avowed environmentalists. They don't mind if lavatory water comes in only one, economically preselected temperature, or if the toilets are flushed by collected rain water. They don't mind if in the winter they have to work in a temperature where tropical orchids thrive (this temperature is a mite below what most of us have been spoiled by). They don't mind walking a few steps to close an insulating panel over a window, or walking a few more steps to open one under the skylights. They don't mind having natural daylight in most of their building and using artificial lighting only in task areas, rather than flooding the whole interior with excessive fluorescent illumination as is normal. They don't mind turning off a light when they leave their offices. And, what is most important, they didn't mind taking the time to learn how to become part of such an environment, but found it to be a joy instead. The building, then, is not for everyone, and that is its real problem. But until more buildings such as this are for everyone our energy problems will never be solved. [David Morton]

Data

Project: Plant Science Building, Cary Arboretum of the New York Botanical Garden, Millbrook, NY.

Architects: Malcolm Wells; David Deppen, project director.

Site: a small clearing in a 2000-acre rural parcel of land in the Hudson Valley.

Program: administrative and research center for arboretum, including laboratories, library, offices, of 28,000 sq ft, to be energy-saving and ecologically responsible.

Structural system: concrete and concreteblock floors and walls, timber-frame sawtooth roof.

Major materials: concrete, timber, gypsum board and glass partitions.

Mechanical system: active solar system supplemented by solar assisted water-to-water heat pump with well-water back-up.

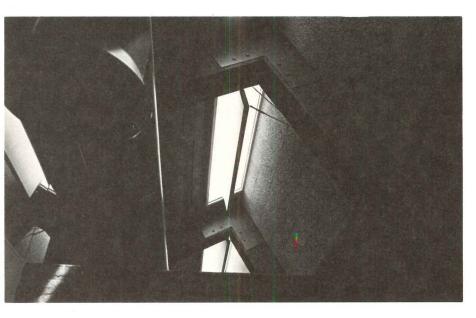
Consultants: EPD/Environmental Planning and Design, landscape; Interspace Inc., Florinda D. Doelp, principal in charge, Jim Dugan, project designer, interiors; Dubin-Bloome Associates, Fred Dubin, mechanical; Enis Y. Baskam, structural; C.B. Strain & Sons, Inc., mechanical subcontractor.

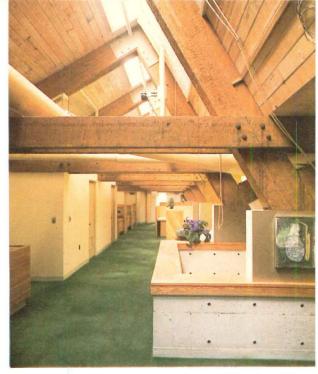
Client: CaryArboretum, Daniel F. Brown, capital projects manager.

General contractor: John Lowry, Inc.

Costs: \$2,600,000.

Except at perimeter, natural light enters from panel-controlled skylights. Photos: Robin Parow, top left; ARTOG/D.G. Olshavsky, others.







Let the sunshine in

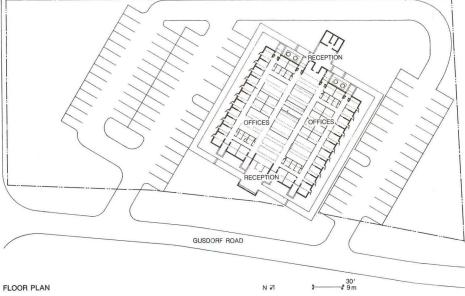
A health and social services center incorporates a passive solar roof into its design that supplies it with 70 percent of its heat and its light.

It is still rare to see public buildings making inventive use of solar methods for heating and lighting. Despite the government's interest in energy conservation measures and solar research, too often those measures just generate ordinary solutions with thicker walls and fewer windows, while solar research is applied mainly to residential design. Recent though such trends may be, exceptions do spring up; new trends take hold. With their design for a state government health and social services center in Taos, NM, William Mingenbach and Harold Benson of The Architects Taos initiated the idea of using solar heating and natural lighting in the building. While the budget, program, and site had already been established before they were hired, Mingenbach and Benson pushed for an energy-conserving concept seeking a \$45,000 ERDA grant awarded to the client for solar equipment. Since the surrounding buildings in the new miniindustrial park in which the center is located rise only one story high, the architects decided that a solar roof system atop a low horizontal structure would offer a most appropriate response.

Basically, the structure, of light steel framing and concrete block, is quite simple and economical—\$46.78 per sq ft for the 12,000-sq-ft space. Because the lack of a continuous roof membrane could present seismic problems, the architects designed multiple shear walls at the perimeter. These split-face block walls add a rugged repetitive texture to the form while expressing the serrated configuration of the roof on the elevations, creating lateral light scoops for private offices.

The ideas being tested here place em-

Photos opposite show west side (top) and entrance front (bottom).



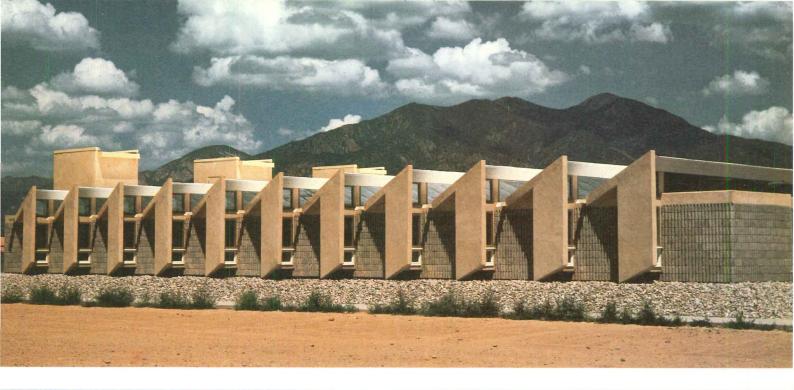
phasis on technical (solar) considerations, though not without formal implications. Mingenbach trenchantly expresses his feelings about the results this way: "The solar heating and daylighting aspects were the most interesting, because they may yield a rationale for architecture that will put to rest the overcelebrated arbitrary design nonsense that has been misdirecting our values for the last thirty years."

Heating the building

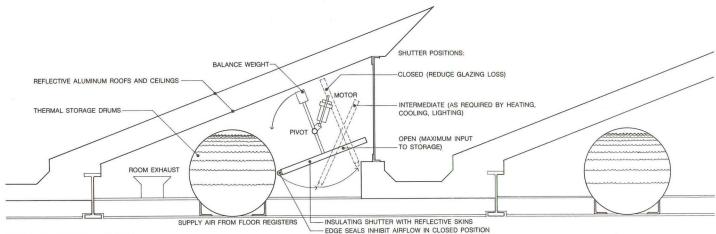
The social services building receives approximately 70 percent of its heat from a combination of direct gain and thermal storage passive solar methods. The means for obtaining solar heat has been concentrated on the roof where a series of eleven serrated monitors glazed on vertical faces admit sun to the interior. The building's orientation southeast begins the solar heating process at the earliest moment of the day. In addition, thermal storage drums resting on the structure's girders and beams are filled with water to store

heat for use on cloudy days. The dark metal barrels hold about 70 lb of water per sq ft of glazing, with 88 percent absorptivity. The architects clad the ceilings of the inclined monitors with aluminum foil mounted on gypsum board—a low emissivity surface for reflection of long-wave infrared light rays. The foil's high reflectivity allows enough ambient light to provide about 70 percent of the general illumination of the office spaces.

In order to modulate the amount of sun and heat coming in the monitors and prevent heat from seeping out of the glazing at night, Mingenbach and Benson devised a shutter assembly. Working in collaboration with solar designer Steve Baer and his firm Zomeworks, they designed 13-ft-long shutters of Hexcel honeycomb paper core with S901 aluminum skin designed to shift angles automatically depending on the particular needs of the building. Thus the shutters can open at a low angle to allow the sun's rays to hit the drum for heat storage, move to an open angle to get sunlight







TYPICAL ROOF MONITOR SECTION

into the room, or tilt up into a vertical position at night to provide insulation to the clerestory glazing. Because of this shuttering device, the R-factor is about 3 on top of the R-2 of the double-glazing.

The "active" ingredient in this passive system is the automatic control for the shutter: Zomeworks would have preferred using freon to activate the shutter, as was done in the Pitkin County airport at Aspen (p. 120). Mingenbach thought it best to have motors separate from the sunshields—pneumatic ones that could take their pressure from the existing HVAC's standard 20 psi.

The "brain" for this shutter control is an analog device, not a digital one, which takes its input from five different sources: an outside ground temperature sensor; a thermal sensor (or "subjunctor"); two optical sensors or subjunctors, plus two thermostats inside the building that receive input from each of six zones. The thermal sensor has an inherent lag of 5 to 20 minutes built into it so that the control mechanisms won't respond to every passing cloud; the optical sensors are given set response thresholds so that they too won't react to "anomalous input like a flock of birds," explains Mingenbach. Once this information reaches the controller, the controller sends its message to the shutter activators through the HVAC pneumatic tubing. A force of 2 oz per sq in. is needed to move the shutter from the horizontal position to the vertical. The controller, designed by Mingenbach, was built and installed by Science Associates of Lama at minimum cost: the controlling device, Mingenbach figures, cost about \$4 per sq ft of glazing or \$0.70 per sq ft of floor area.

Naturally, the shutter seal must fit fairly closely to lower the U-factor. Steve Baer designed a rolled silicone cloth seal, tailor fitted for the job. Since it is not part of an assembly with frame, the device—along with the wood-block bumpers to stop the

shutters—does lend a certain ad hoc quality to the design. But it seems to work.

The solar heating devices maintain an average temperature differential of 40 F between outside and inside on a sunny day in January. Electrical heating provides supplementary heat. Despite the backup, Mingenbach points out, the temperature rarely exceeds a seven-degree swing for inside offices when the mean temperature outside is 30 F. The placement of earth berms around the building perimeter and the use of splitface concrete block walls, which preserve a thin surface film of air, help hold down that swing.

Cooling it

To cool the building naturally during the summer months, The Architects Taos plan to install rock regenerators next to four vertical mechanical stacks at the north end of the building. In the cooling-by-evaporation process, a timed amount of water linked to the pulse cycle of exhaust air flows around the rocks. Then the cycle is reversed with fresh air taken in over drying rocks. Since only about 40 days are considered really hot, the evaporative cooling process should keep the building cool most of the time, even raising the humidity level to a comfortable percentage. Mingenbach points out that the roof design would work well in altitudes like Denver, but would require special exterior shading in hotter places like Albuquerque.

Drainage

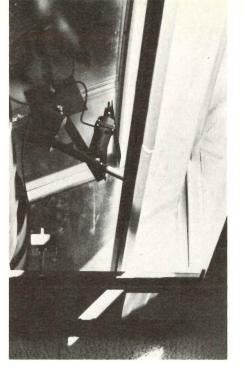
To drain the roof the architects placed gutters between the eleven monitors. The gutters lie over 11/2-in. batts to induce any snow accumulation to melt from the building's heat (there are 6-in. batts elsewhere on the roof). An internal drainage system, plus outside scuppers for overflow, means the building can outlive a 10- to 12-in. snowstorm with little problem. While the snow conditions at Taos often

border on the severe, the building's valley location keeps it free of heavy drifting.

General application

Despite individual climatic factors that have to be considered, the roof system does make sense for the many one-story buildings—spec office buildings, supermarkets and other commercial storesthat have become part of suburban growth. The possibility of retrofit could be explored with these horizontal structures.

The architecture of the state services building, based as it is on a modular grid plan, attests to the adaptability of this solar concept to the conventional buildings. The architects confess that energy efficiency could be greater: they had to omit some features that would have otherwise furthered the energy efficiency of the building. For example, the clients preferred a private subdivision of spaces rather than an open plan, and wanted carpeting rather than heat-absorbing masonry floors. From the downright commonplace quality of the details, finishes, and furnishings, one can also see the obvious concessions made to a tight budget. Thus the building really owes its only drama to the natural light pervading the interior or the the unusual sight of oil drums in the ceiling. (The exterior attains more visual interest with the serial pattern of the serrated roof and the lateral lightwells, plus the textured block walls.) It is inside, therefore, that one wishes more had been done with colorthe necessarily dark mat colors of the storage drums focus attention on the deadened colors of the metal partitions. The absence of views puts a greater burden on the interior landscape. Nevertheless, the building itself provides a model to learn from—both in terms of solar heating, lighting, and natural cooling, and in terms of formal implications emanating from these technical solutions that bear further investigation. [Suzanne Stephens]





Light troughs admit sun to interior conference rooms (top, right) as well as to peripheral offices (right), which also receive light through side walls.

Data

Project: Mary Medina building, Taos, NM. **Architects:** The Architects Taos; William Mingenbach, Harold R. Benson, principals in charge.

Program: to house social services and income support agencies for the state's Health and Social Services Department in 12,000 sq ft with two separate entries for food stamps and welfare recipients (south entrance) and social services clients (north side).

Site: two acres, part of a mini-industrial park in a semirural but newly developing area of Taos. **Structural system:** light steel framing supporting wood joists and plywood roof over S.O.G. floor. Foundations of reinforced concrete; walls of reinforced block.

Major materials: splitface block; stucco finish; foil-faced gypsum board (foil side out) for ceiling surfacing; aluminum membrane over asphalt sandwich for roof surfacing; 350-gallon shipping containers used for thermal storage.

Mechanical system: heating by direct gain and water storage passive solar approaches with electrical heating backup. Vertical rock regenerators to be installed to cool building through evaporation.

Consultants: DeLapp Engineering, structural: Lewis Poe, electrical; Zomeworks, solar control shutters and motors.

Client: State of New Mexico, Department of Finance and Administration, Sam Poole, State Architect; Health Social Services Department.

Cost: \$561,415, including \$45,000 from ERDA to the State of New Mexico for solar equipment; \$46.78 per sq ft.

Photography: Israel Stein.



First impressions

The new downtown airline bus terminal planned for San Francisco will be as dramatic in its bold form as it will be explicit about its energy conservation.

Last year San Francisco's downtown airline bus terminal handled two million passengers, and the worn-out, vaguely Moderne structure fairly burst at the seams. As the city's tourist trade booms, and as its airport expands, the terminal would stand to get even heavier use in the future. It is already projected to accommodate a half-million more travelers next year. This, coupled with the fact that the San Francisco Hilton owns the land the terminal occupies and wants to expand its adjacent hotel onto that site, dictated the terminal's move. A new site has been found that is one block east of the present one, across the street from the Hilton, a block closer to Union Square and a BART station, and adjacent to the proposed Yerba Buena Convention Center. If this sounds like an ideal location for a new terminal planned to handle up to 2400 people every three minutes, it is.

The new facility that will soon enter construction is an energy-conserving, expandable, high-tech, people-moving machine designed by Jacques de Brer and John Ellis that is more of a sculptural assemblage of sleekly engineered components than it is a building in the traditional sense. It is a bold architectural gesture that could only have come about through daring clients who wanted, and will soon get, a dramatic and striking new gateway for their city. As the builders of railroad stations knew in the past, these clients also know that the image of such buildings plays an important role in conditioning one's perception of a city, even before actually entering it. Although this is something the airlines have yet to learn, this building should help to expose other

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such facilities as the hopelessly banal processing sheds that they are, which do little for their communities or for those who use them, and which only extend the inhuman airport image into inner city.

But image is not all. In showing a rare understanding of travelers' needs, the clients' program clearly stated that the process of transferring from taxis or cars to the airport bus, or vice-versa, should be as simple and enjoyable as possible. In following this requirement, the architects have organized the building essentially as two long pedestrian tubes for incoming and departing passengers. These glazed concourses extend from the front ticketing, snack, and information area to the rear of the site, supported above a natural drop in the land by steel trusses spanning between cylindrical columns on 50-ft centers. Elevators or cable-supported-and-braced ramps lead from the concourses to the lower level where arriving buses discharge passengers under one concourse before proceeding under the next one to pick up

departing passengers. The entire complex is arranged so that arriving or departing cars, taxis, buses, or travelers on foot never come into conflict with each other.

The heated portions of the building, such as the front section and the waiting rooms between the concourses, are clad with glazing and porcelain-enamel panels and, in accordance with California law, insulated. Heat for space and domestic hot water is supplied by hot water from four flat-plate solar collectors of 1250 sq ft each that are mounted in due south orientation above the concourses and on their supporting structure. The climate does not demand air conditioning, but the building is ventilated naturally through manually operated louvers.

In the near future, the earliest image many people will have of San Francisco will be conditioned by a structure of dramatic sculptural quality designed to be explicit about its use of energy-conserving systems. That should not be a bad first impression. [David Morton]

Data

Project: Downtown Airline Bus Terminal, San Francisco, Ca.

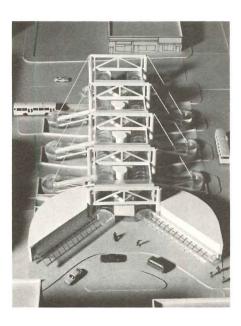
Architects: Jacques de Brer and John Ellis, San Francisco, Ca.

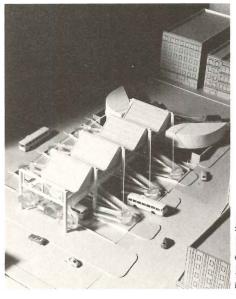
Program: a new airport bus terminal to be as convenient for passengers as possible and to be designed as a dramatic gateway to the city. **Site:** on a city block downtown.

Structural system: steel trusses spanning between cylindrical steel columns 50 ft on center; pedestrian ramps suspended and braced by diagonal cables from the tops of columns.

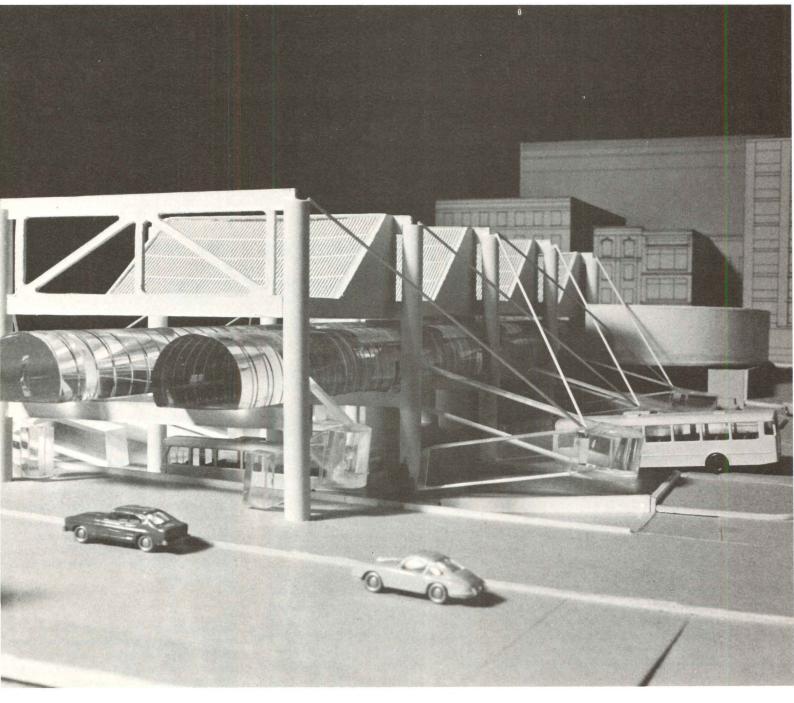
Mechanical systems: 5000 sq ft of flat-plate solar collectors provide heat and domestic hot water; manually operated ventilation.

Major materials: painted steel structure, porcelain-enamel cladding panels, glazing. **Client:** Airporter Bus Company.









Conspicuous reduction

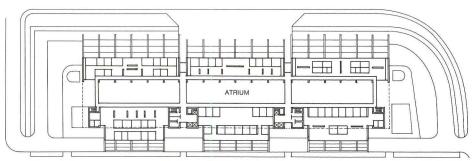
Office buildings of any appreciable scale haven't often embodied energy as design determinant to date. A project in Houston by Caudill Rowlett Scott goes a long way.

Most realized building designs that have been given their form—to a greater or lesser degree—because of energy concerns have been for low or small-scale projects. Some larger examples have begun to appear, but some highly visible ones, such as New York's Citicorp, have failed to materialize. Few larger projects have been conceived from the beginning with energy and design sharing top billing.

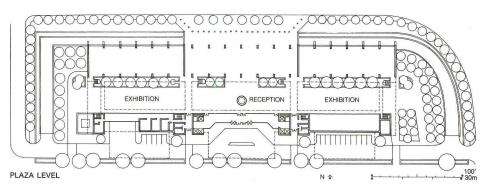
Seldom, as yet, do the recognized "leading" firms pay more than lip service to anything but pure design. So it is of more than passing interest when a company like CRS—publicly on record as striving for a spot on "the top ten" design firm list—melds energy with design. Their design for a Houston office building does just that, with more grace than most we've been shown before.

It must be stated up front that the design probably won't get built, at least for the original client. Our hope is that lessons can be learned about building in a climate like Houston's; and maybe there's another interested client in the bushes. It is equally clear that the proposal would probably attract only the quality-minded developer, not the build-it-cheap-and-quick type. This is not to imply that the architects paid no heed to economics, but a cheaper spec building would be attainable—at a price in both energy and, naturally, design.

Two symbiotic aspects of the scheme which blend design with conservation of resources are the atrium space and the Malkaf Concept. The latter mandates the trapping of prevailing breezes in wind tower or scoop fashion, channeling air down through the atrium, and discharging it at the leeward side. Thus a major form



TYPICAL OFFICE FLOOR



determinant in turn blends with local ordinances and solar orientation needs to further shape the concept.

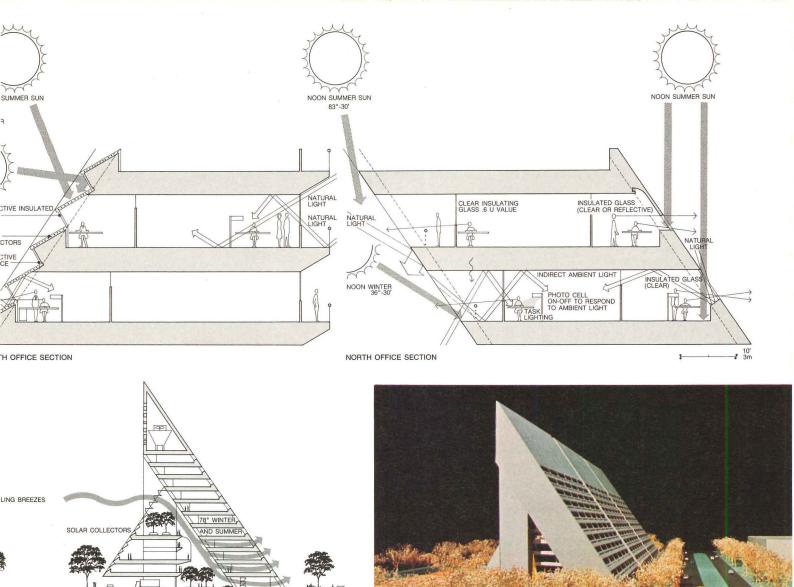
Atrium-facing spaces would not be denied outside awareness, either visibly or in ventilation. Operable windows would provide natural illumination while enabling major periods of natural air tempering as well. Although atriums understandably have become popular lately, few have recognized the natural ventilation they promote. The next time you're in a hotel with a room door facing a vast atrium, see for yourself, if the windows open.

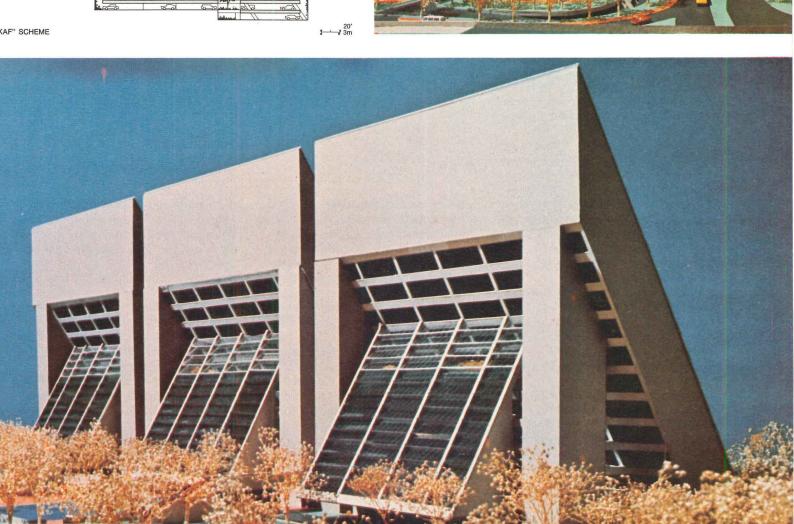
Other considerations in this scheme called for a computer control center for monitoring and/or operating mechanical, security, and weather functions, making appropriate adjustments to meet changing climatic and occupancy loads. Active solar collection would occupy 25,000 sq ft of surface stepped down the south face of

the building. The collectors were projected to supply all "domestic" hot water needs, and some heating and cooling.

Combined with the use of overhangs, insulated or reflective glass, and some bounce light principles (reflecting light for illumination and for solar collectors), most current energy-related thoughts have been assembled in this one design proposal. Clearly, this part is in large measure what P/A's Award Jury was looking for last September (P/A, Jan. 1979, p.65). It combines energy, site, and aesthetics in a handsome package. Any clients listening? [Jim Murphy]

Canted south wall (right) features active solar collector arrays below the operable atrium sash. Reflective panels at spandrel locations amplify insolation at low sun angles. North façade is also sloped to allow the natural light to enter.





Cold land, warm heart

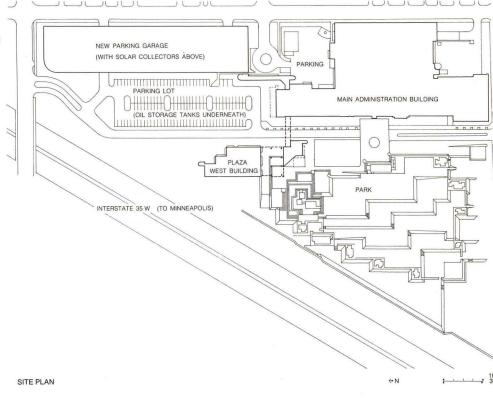
A control systems equipment producer puts its money where its mouth is with a design by Hammel Green Abrahamson that includes this country's largest high-temperature solar energy system, built without any government funding.

Those of us from more or less temperate regions of the United States are often astonished by cities in our more extreme climates. For example, New Orleans in August can leave the visitor wilting making one wonder how the city ever got built in the first place. Minneapolis is the same, but different. In the gift shop at Twin Cities Airport there are T-shirts emblazoned with the name of the city spelled out in snow-covered letters dripping with icicles, and with good reason. This is a city where the weather in the wintertime often hovers around zero F, and only 20 below or so is considered really cold.

Yet, the pervasive sense of civic pride and public industriousness in Minneapolis is immediately obvious, leading one to wonder about the social effects of an extremely cold climate as opposed to an extremely hot one. Whatever the answer, the difference is clear, and it is reflected in the architecture and planning of the Twin Cities region, which possesses good measures of order, cleanliness, and simplicity, values not in overly abundant supply in other metropolitan areas in this country.

The best of intentions

Typical of those conscientious local attitudes are those of Honeywell, Inc., the control systems equipment manufacturer that since the turn of the century has been a major factor in the economic life of Minneapolis. This corporation has shared the socially responsive practices of many companies in that part of the United



States, and in the recent years of rising energy consciousness has found increasing opportunity to put into use for itself those pulbic actions which speak far louder than words. Not surprisingly, Honeywell's business these past few years has been very good indeed, and eventually the company found it necessary to expand its corporate headquarters not far from downtown Minneapolis.

The firm had already chosen to remain on the site it has occupied for over 65 years, rather than relocate in a new building elsewhere: the more common practice that results in so many garish new corporate symbols each year. This decision to retain and refurbish its existing headquarters represents a significant endorsement of energy conservation to begin with, since

the considerable expenditure of energy on redundant new construction each year is an underpublicized drain on our dwindling resources. But the commitment to an active solar energy heating and cooling systerm was not part of the company's original expansion plan.

Honeywell retained the Minneapolis firm of Hammel Green Abrahamson, Inc., to design a new eight-story building with approximately 100,000 sq ft of additional office space adjacent to the converted factory buildings that serve as the corporation's executive offices. Although in their original scheme the architects were mindful of the impositions of the climate, the new building was not planned initially to be actively energy-conservative. In fact, more attention was being paid to such problems

as visually unifying the collection of undistinguished existing structures with the new Plaza West building, and adjusting the massing of that addition so as not to block the view of the Minneapolis skyline from the executive offices in the old converted factory building next to it.

Here comes the sun

But eventually Edson W. Spencer, Honeywell's chairman and chief executive officer, decided to go with an active solar energy system as a highly visible parallel to the firm's equally active role in promoting (through its own products, of course) more intelligent energy use. Honeywell's experimentation with regulation devices, such as the computerized control system that monitors the solar and HVAC system in these buildings, makes this effort a clear case of enlightened self-interest. Since the architects were well into the design phase of the project when this dramatic program change was made, the results-which might be termed pre-occupancy retrofit—were not entirely satisfactory in terms of realizing the maximum potential of an active solar energy system.

One of the first problems the architects faced, of course, was where to put the large field of tracking solar collectors that would be necessary to fully heat (and cool, in summer) the new eight-story building. The stepped-back design of the Plaza West tower did not provide sufficient space for all the necessary collectors, so it was finally decided to place them atop the five-story parking garage that was planned for a site adjacent to the new building. The area available on the uppermost story of the garage was perfect—an unbroken space just about the size of a football field. That space was additionally desirable since there was no need to support the collectors over built-up roofing (which the garage does not have), though as built the collectors span the width of the structure as they would to avoid roofing. Occasionally, though, the Plaza West building casts a shadow over the solar collectors, blocking them from their variable energy source, and sometimes the sawtooth configuration of the adjacent collectors does that, too.

Fortunately, man-made eclipses do not happen too often, and for the most part the system has been operating quite well in its first few months of operation. The high-temperature solar energy system differs from other active solar systems not so much in its method of collection, but in its method of heat transfer. The reflected rays of the sun are trained onto receiver tubes plated with a selective black chrome. Within those tubes is Caloria HT 43 oil, a special heat-transport oil (heated to approximately 350 F). The collected thermal energy is transmitted through that oil to heat-transfer equipment on the first floor of



Original Honeywell buildings (above right) were renovated as part of overall improvement plan.



Plaza West building (above and below) faces newly landscaped park by M. Paul Friedberg.



Honeywell Plaza, Minneapolis

the Plaza West building. That equipment includes one of the few Rankine cycle engines in operation in this country, which is used for the solar cooling system, providing 84 percent of the annual cooling energy for Plaza West. (A Rankine cycle engine is basically a turbine which can convert heat energy into electricity: in this case, the collector heat is converted into electricity for the cooling machinery.)

The solar heating system operates on a more conventional shell-and-tube heat-exchange system, which provides 53 percent of the building's annual heating energy, and 100 percent of its domestic hot water. Storage tanks for the heat-transport oil are located under the surface parking area between the garage and Plaza West, the only evidence of their location being the patches of melted snow that dot the lot in subfreezing weather.

Private collection agency

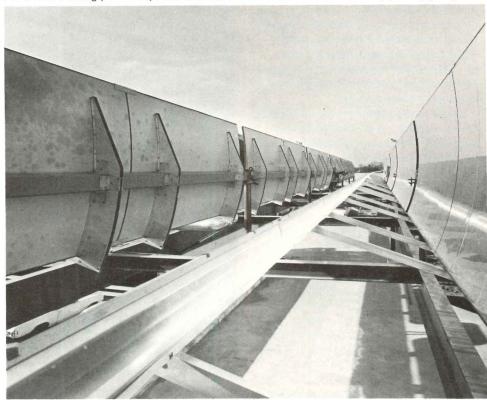
The Plaza West building did, to be sure, undergo some significant changes before it was occupied. Hammel Green Abrahamson was responsible for the design of the building itself, but not its interiors, which were done by a local interior design firm. The first scheme for the office interiors was a traditional closed-office plan, which, upon completion, was ordered ripped out by Ed Spencer. Good for him. The few areas where that arrangement still remains to be altered are nasty little warrens of tight corridors and cramped cubicles. By contrast, the open-plan offices on upper floors could be juxtaposed with the previous scheme as a definitive illustration of the benefits of open office planning.

The design of the project as a whole is adequate—better, actually, than many large office buildings built in America—but it is by no means a very important aesthetic achievement. Its importance lies elsewhere. Its energy system, the largest of its kind in the United States, is a significant step forward quite aside from its actual conservation of resources. Built without any government aid, it shows how the private sector can, and indeed must, begin taking the initiative that governmental sources cannot be expected to provide forever. Furthermore, Honeywell's broad conception of what constitutes conservation is likewise heartening. This farsighted client realizes that in retaining and upgrading the existing buildings and the surrounding neighborhood it is furthering the cause of conservation in equally important, if less immediate, ways. The new Honeywell headquarters complex provides an encouraging glimpse of what might happen if such civic virtues could widen into national ones. [Martin Filler]





Plaza West building (above left) sometimes casts shadow on solar collectors atop parking garage.



Collector assembly (above) focuses sunlight onto receiver tube at focal line of parabola. Oil within tube is heated to about 350 F by reflected sunlight. Reflector portion of assembly (top right) is made of aluminum honeycomb sandwich covered with adhesive aluminum acrylic film.

Data

Project: Honeywell Plaza, Minneapolis.

Architects: Hammel Green Abrahamson, Inc.

Client: Honeywell, Inc.

Site: urban campus adjacent to highway and low-rise, residential neighborhood.

Program: remodeling existing office buildings and construction of new office building, parking garage and solar energy system in accordance with energy conservation policy of company. Solution involved construction of high-temperature solar energy system for heating and cooling the new eight-story, 106,000-sq-ft office structure.

Structural system: 7½-ft post-tensioned concrete slab on poured concrete columns spaced

on a 30' x 25' base.

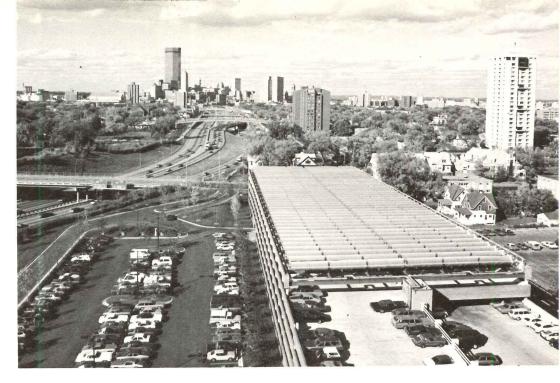
Major materials: brick masonry exterior walls, gypsum board interior walls, carpeted floors, acoustical tile and linear metal soffit ceilings, elastic sheet PVC roof.

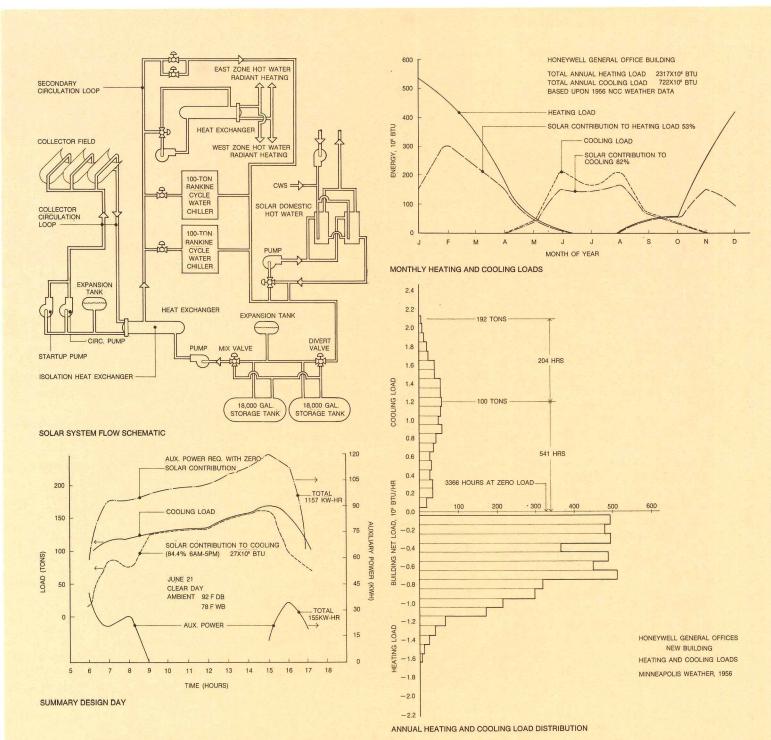
Consultants: Ellerbe Associates, Inc., mechanical and structural; M. Paul Friedberg, landscape; DVR&W Inc., interior design.

General contractor: Bor-Son Construction

Cost: total approximately \$12,850,000. Approximate subtotals: renovation of existing structures: \$1,850,000; parking garage: \$2,400,000; new Plaza West Building: \$4,500,000; landscaping and surface parking: \$2,000,000; solar system: \$2,100,000.

What is wrong with this picture? The contradictions of our energy crisis are neatly summarized in the Honeywell project (right). Collectors for solar system surmount five-story parking garage housing over 1000 cars, with surface parking for thousands more adjacent. In the background, an eight-lane highway leads to downtown Minneapolis. Although Honeywell's enlightened approach to energy consumption points to more intelligent use of our resources, the predominance of the private automobile as America's primary means of transportation remains. Our dependence on vast amounts of energy to support that vehicular habit far outstrips all our conservation efforts.





Suburban renewal

Joyner/Bernardo Associates takes a low-grade commercial structure and converts it into a facility that is both low-cost and energy-conserving.

Most high-style furniture manufacturers once projected a rather uniform image based on an aesthetic of pristine modernity, costly opulence, and indifference to practicality at the expense of economy, function, and adaptability. Such attitudes were likewise projected by the spaces occupied by these companies, which more often than not equated goodness with newness above all else. But a few farsighted (and shrewdly practical) contract furniture firms—such as Helikon and Sunar—have broken out of that obsolescent mold lately and have moved into refurbished older buildings that far surpass those of many of their competitors.

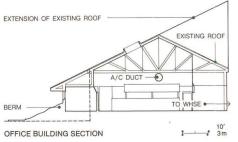
Now Stendig International, Inc. has joined that trend and has moved its factory, warehousing, and administrative operations (and those of its B&B America division) to a remodeled World War I munitions warehouse in the New Jersey flatlands not far from New York. Seeking to consolidate the functions previously housed separately in Brooklyn and Manhattan, the client asked architects Bob Joyner and José Raul Bernardo to find a structure capable of economical adaptation to their needs. Eventually they found an industrial park in Northern New Jersey with old but sturdily built armament storage buildings that the owners—Federal Business Centers, Inc.—were willing to remodel to Joyner/Bernardo Associates' energy-conscious specifications.

This project is as noteworthy for what was retained as for what was changed. The architects decided to keep the deeply sloping roof on the building's southern exposure, ideal for possible future installation of active solar collectors, an option which





Original roof line of old structure (above left) is echoed in renovated building (above right).



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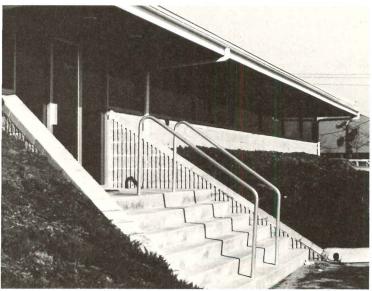
was rejected as being beyond the price range of the low-budget project. A berm was raised against the low southern wall beneath that roof, meeting a narrow strip window that runs the length of the building. The insulating effect of the berm and the minimal amount of glass exposure under the generous overhang of the roof give the offices within a very good head start at energy efficiency.

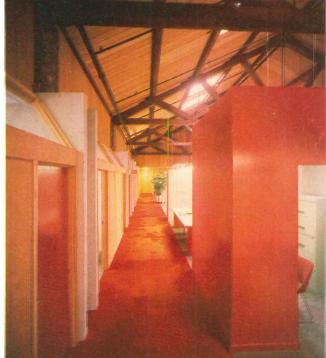
The interior design of this part of the facility (the storage and factory areas are located in a conventional 1960s warehouse building attached to the back of the office section) likewise retained elements of the existing building which were well worth keeping. The bold wooden trusswork of the original structure has become the most dominant design element of the office area, the old brick piers have been cleaned and highlighted, and the spatial integrity of the interior has been strongly reemphasized. A row of private offices and conference rooms is strung along the southern wall behind the strip windows, with the main secretarial area behind that

in the center of the building. The light from those strip windows is admitted further into the interior via transparent glass transoms and panels, with more light filtering down into the large open space from a few small, but effectively placed, skylights on the south-facing roof.

The interior lighting is so well executed that it should not come as a surprise to know that Joyner/Bernardo Associates specializes in lighting design. Ambient light is used exclusively in the open clerical-pool areas and in the private offices as well. The architects believe that with effectively designed ambient illumination no task lighting is necessary for most office work. Light fixtures at Stendig are, for the most part, rectangular "trapeze" units that are suspended from the rafters on thin chains, creating a sense of overhead enclosure that helps mediate between human scale and the cavernous roof space.

Heating, cooling, and ventilation received no less careful attention. The walls and ceilings were insulated and paneled in





Berm (above left) flanks entry. Outside row of offices (above right) adjoins employee dining area (below) within large open office space.

cheap, rough-cut fir plywood, a material that is surprisingly handsome, and which has insulating properties as well. The bold orange forced-air duct that shoots down the length of the building is placed uncommonly low—just overhead at the same level as the light fixtures—in order to make the air conditioning most efficient. And to prevent excessive heat loss in winter, oldfashioned, rotary-blade fans have been placed at the apex of the ceiling to recirculate downward the warm air that has risen.

The energy conservation methods used here are simple, cheap, and effective. They are not dependent on expensive, energy-consuming technologies, but rather proceed from common-sense, "low-tech" strategies that could be easily applied in most buildings being built or remodeled today. Energy conservation means not just the conservation of energy alone, but also of building materials, labor, and money. That this good recycling job cost only \$12 per sq ft would seem nothing short of miraculous these days if Joyner/ Bernardo's recent remodeling of Stendig's New York showroom (P/A, Dec. 1978, p. 23) had not cost only \$7 per sq ft. As for the encouragement of better energyefficient design, that could be the big non-payoff. [Martin Filler]

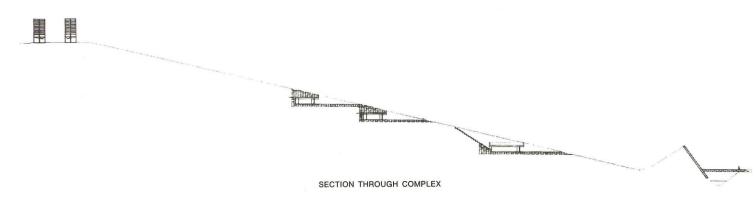
Project: Stendig International, Inc. factory, warehouse and offices, Edison, NJ. Architects: Joyner/Bernardo Associates. Site: suburban industrial park. Program: renovation of warehouse into offices for a contract furnishings manufacturer. Structural system: existing timber trusses.

Major materials: concrete exterior walls, plywood interior walls and ceilings, carpeted and tile floors (see Building materials, p. 204). Consultants: Valk & Keown, AIA, architects. General contractor: Raritan Center, Inc.

Cost: Approx. \$100,000; \$12.35 per sq ft. Photography: Robert Perron, except as noted.



Working the land



Earth is cut and mounded into bold forms in a plan by Emilio Ambasz for an energy self-sufficient multifamily farm

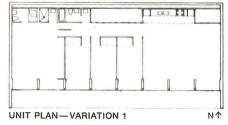
On a site about 30 miles west of Savannah, eight families are planning to establish a cooperative farm. Until it becomes economically self-supporting, they will retain part-time jobs in the city; as it succeeds, they expect six more families to join them. In designing a setting for this return to the soil, designer Emilio Ambasz has reconsidered the form of the rural community.

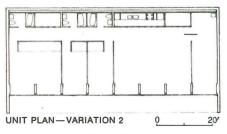
Living units will be dug into the south-facing slope, insulated by the earth on all but the exposed sunny side. Excavated earth will be used to form a large mound which will support—at minimal cost—an array of helio-voltaic panels sufficient in area, even at current low efficiencies, to satisfy the settlement's energy needs.

The design of the individual living unit takes advantage of the slope, the south side of each one opening onto a level terrace. The generous interior space—80 ft long—can be laid out as the occupant wishes, with bath and kitchen facilities located along the "wet" wall to the north.

The building technique for the houses is similar to that used for swimming pools: concrete floor and wall slabs rest on beds of cast sand; a liner of fiberglass, fused at the seams, is wrapped entirely around the buried surfaces. A grid of iron columns supports the vaulted concrete roof. Drain pipes in the gravel above the vaults carry off water, which is collected in a stream along the south edge of the complex, supplying a small artificial pond. An underground "canopy" of fiberglass panels, extending 10 ft beyond the perimeter, keeps water from soaking the ground around the structure.

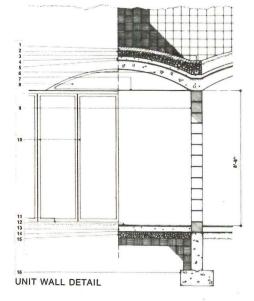
Access to the complex is by a road that ends in a sunken parking area—with adjoining underground sheds for trucks and







1 2 in. clay. 2 4 in. gravel. 3 4-in. dia. tile pipe. 4 2-in. lightweight concrete fill. 5 continuous membrane waterproofing. 6 concrete vault. 7 ½-in. dia. tie rod. 8 operable window. 9 8-in. reinf. concrete block. 10 center-pivot doors, wood-framed. 11 4-in. sill. 12 quarry tile. 13 concrete slab on grade. 14 fiberglass membrane. 15 4-in. gravel base. 16 concrete foundation.



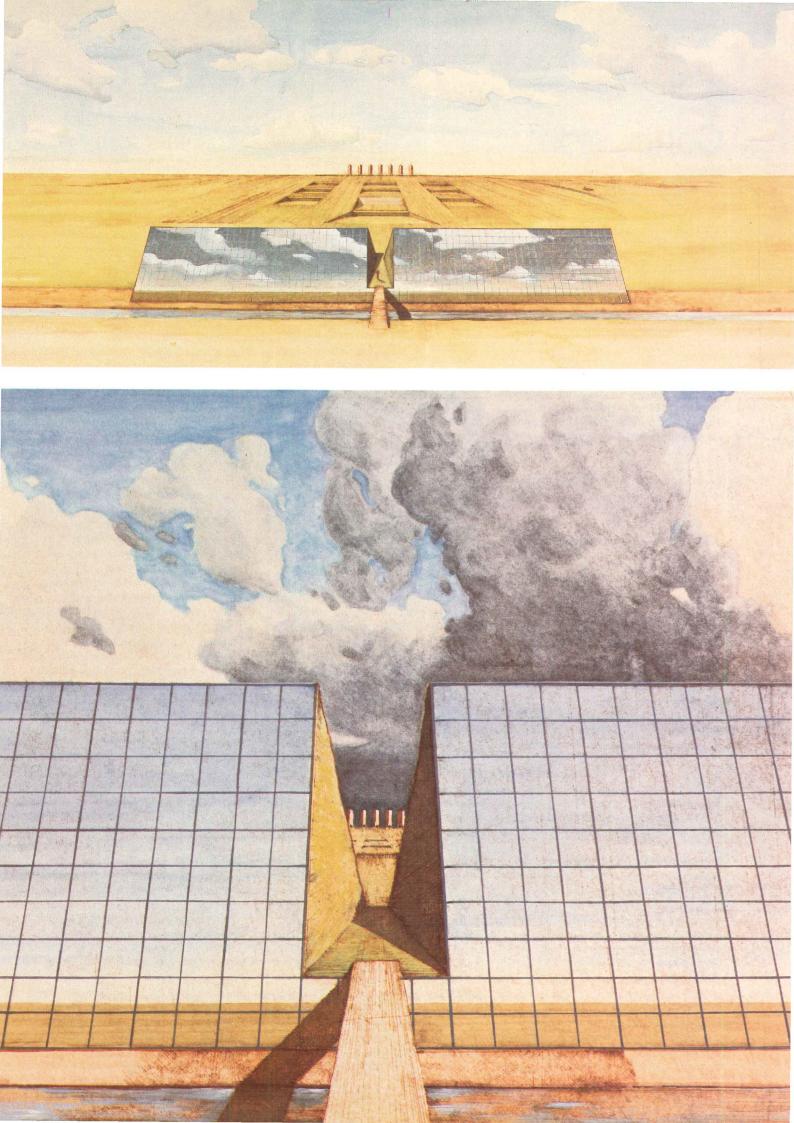
tractors—from which one approaches over a footbridge across the stream. The path then passes through a cleft at the midpoint of the collector mound. (Walkways within the complex will be paved with flagstones once paths have become visibly established.)

Immediately ahead of this gateway is a community building, recessed into the ground like the houses, but exposed on both north and south sides. Here, in spaces to be divided to suit the users, will be communal playrooms, laundry facilities, and a kitchen for community breakfasts and lunches. Since some settlement members are performers, the slope to the north of this building will be stepped as an outdoor theater, using the roof as a stage.

Along the north edge of the complex, at its high point, will be a row of grain silos. These have been placed to take advantage of winds, which will be admitted through openings to dry the grain in the ancient way, rather than by using gas heat in an enclosed space, as is usual today.

The effect of Ambasz's cut-and-fill scheme will be to balance the amount of earth dug out with the amount mounded up for the collector, while subtracting almost no area from the arable acreage of the farm. The structures that rise above the fields—the row of silos and the energy collection mound—are strongly organized around the axis of the entrance. They define the boundaries of the complex and symbolize its underlying premises. "One collects the land's produce, the other stores the sun's rays," observes Ambasz. "One is background, the other is foreground; the joy of living off one's land and working in one's house creates the place in between." [John Morris Dixon]

The farm's landmarks—its solar collectors and silos—define an axial layout (top, opposite) that is revealed at the main entrance (bottom).



Conclusion: The future is rich

Energy-conscious architects nationwide view the present and forecast the future. The architectural implications of energy lead us to conclude: the future is rich.

The oil embargo of 1973 was a challenge to change. That challenge has been met in various ways by American architects. Some have avoided it; some have accepted it; and others have eagerly welcomed it. The oil crisis pulled the plug on many architectural firms; the effects of the building drought are still being felt. Some architects, however, saw energy consciousness as an opportunity for survival and jumped in with both feet. For another segment of the architectural community, work in energy-conscious design preceded 1973. The crisis served only to accentuate their beliefs and accelerate their progress.

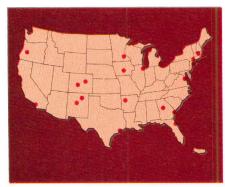
A fitting ending to this issue is to speak directly with some of America's most promising energy-conscious architects. Of course men like Fred Dubin, Ralph Knowles, and William Morgan represented their own segments of the national picture, as have the projects and buildings just reviewed. We have selected eight additional architects to respond to two specific questions:

- 1. To what degree has energy become a serious design influence in the architecture of your region?
- 2. Because of the intimate correspondence between the climate, the fuel costs, and energy usage of our buildings, what regional characteristics can we expect from the architecture of your region?

Their answers are as follows:

Rocky Mountain state of the art

Richard Crowther: Our nation is now in a political, economic, societal, and industrial energy revolution. Architecture for the most part is energy dependent and energy



BUILDING SITES AND AUTHORS IN THIS ISSUE

intensive. Older homes and buildings constitute much of the built environment that can survive economically only by extensive modification and alteration to decrease their energy demand on our finite fuels. Most architects do not appear to be aware of the intensity and depth of our national energy revolution. Statements by architects clearly indicate that they have a level of concern, but that aesthetic design is their prime focus.

There is an above average representation of solar projects in our region. Most of these are residential. Our solar and climatic responsive projects exhibit a visual generic commonality. As the seasonal path of the sun, specific site topography, and on-site natural alternative energy sources become primary to design, architecture will acquire a microclimatic regional form.

Commercial and institutional solar projects have been few in number. Greater attention has been given to energy-conserving techniques rather than the use of solar and other alternative energy systems.

It is inevitable that architecture will evolve towards a regional design ethic. As the realization develops that architecture, its occupancy, its interior, its site, its microclimate are synergistic energy systems, and fossil fuels are finite, solar and other alternative natural energy uses and energy

conservation will become dominant. The West and Southwest always have been closer to nature. This provides a regional cultural reinforcement to the imperative necessity of developing a holistic energy-responsive architecture.

Recognition of architecture as a regional design depends on its common denominators of scale, form, configuration, penetrations, surface, color, and details. The microregional energy forces of sun, air, earth, water, and living organisms as the ingredients of an energy-responsive architecture will give it a microregional character. As underground architecture or an increase of on-site or local materials is used to conserve energy, the regional image of architecture will be reinforced.

Climatic regional design will be a viable reality when architects, designers, and builders accept energy as a prime consideration and when the cost of conventional energies becomes a substantial burden.

New England state of the art

Gorden F. Tully: The almost moribund builders' housing industry is paying scant attention to energy. Custom houses are showing an expectable orientation toward energy, because the owners have more discretionary income and have done their homework. Six-inch studs are increasingly common, the use of heat pumps is on the upswing, large glass areas face south, and electric resistance heating is used sparingly. By far the largest use of active solar in this region is in the form of hotwater heating retrofits.

An interesting indigenous form of architecture is the rural solar house, often designed and built by nonarchitects, and exhibiting extraordinary measures for the accumulation and use of solar energy. Frequently wood is used as the backup heating, and these houses are advertised as 100 percent solar (wood is considered a form of solar energy).

Thomas Strat is a principal in Thomas Strat & Associates, Troy, Mi. He has been honored by the State of Michigan Senate for his work in solar energy (1977). Shown here (1) is the Macomb County Satellite Services Building, Warren, Mi, an active solar design conceived with the aid of computer analysis.

W. Ennis Parker is president and chief operating officer of Heery & Heery, Architects & Engineers Inc., Atlanta, Ga. Shown here (2) is the Georgia Power Company Headquarters designed by the firm. When finished, the 24-story office tower will use its solar collectors to help reduce operational costs by supplementing the building's cooling, water-heating, and spaceheating systems.

Richard L. Crowther is principal in the Crowther/Architects Group, Denver, Co. A pioneer in the field of energy-conscious design, his multifaceted adherence to environmental principles make him a leader in the field. (3) Cherry Creek Solar Office Building, Denver, Co., demonstrates Crowther's unique design approach. It incorporates both active and passive solar. (P/A, Dec. 1977, p. 77).

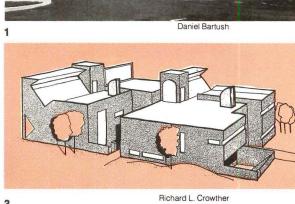
James Lambeth is principal in his own architectural firm and Professor of Architecture at the U. of Arkansas, Fayetteville, Ar. His solar architecture has earned him international acclaim and consulting work. A well known example of his work with solar lens design is (4) the Strawberry Fields Apts., Springfield, Mo. It is one of the few multifamily uses of passive

Since the owner or developer is much more conscious of his return on investment, he has been very slow to incorporate solar heating in large-scale projects. The **HUD** and **DOE** demonstration programs have provided most of the activity in this area, usually consisting of sophisticated active collectors mounted on expensive steel frames at the top of high-rise buildings, or active systems incorporated in new low-rise buildings. A few entrepreneurs have incorporated solar heating on their own, but this is the exception rather than the rule.

Some of the recent spate of condominiums, both new and conversions, exhibit more than the code minimum of energy conservation, and some of these in the luxury range are beginning to incorporate active solar systems. Passive solar in multifamily housing is practically nonexistent, both for intrinsic technical reasons (the difficulty of transferring heat from one overheated apartment to another) and because of high land costs and restricted sites, which do not allow the optimum orientation of buildings.

Aside from a few exceptions, and a general incorporation of ASHRAE 90 standards, energy is not a major design influence on New England architecture. It should be noted, however, that because of the severe climate in the Northeast, energy







James Lambeth

has always been an issue to some extent; and the pressure is certainly on as fuel costs continue to rise.

There seems to be little evidence that architecture will change dramatically in "style" as a result of energy in the foreseeable future. In general, other restraints such as land use, building economics, the reuse of existing buildings, etc., are going to play a far larger role in determining the nature of future architecture in New England. Naturally, there is going to be a period of exaggerated experimentation with the new energy forms, just as there is when any new technological innovation appears. But when things settle down, New England architecture is likely to look very much the same after the "energy revolution" as it does now. Perhaps some of the designs which bucked the climate in an aggressive way, relying upon a heavy dosage of mechanical equipment, will disappear from the marketplace. But such designs are exceedingly rare—"typical" New England houses look either like barns or like historical prototypes; "typical" New England skyscrapers tend to have a good deal of masonry on them; "typical" industrial buildings will still have metal siding even if there is 6 in. of foam insulation under them, etc.

It is arrogant for architects to believe that stylistic issues and the use of bizarre

energy-collection devices are going to determine the shape of regional architecture in the future. Architecture is going to be shaped in the near future as it has been shaped throughout history, by the society as a whole acting through its entrepreneurs, speculators, landowners, and banks, with the architect doing what he can to give shape to these disparate forces and to represent human needs where they are left out of the financial equations.

People are skeptical of steamroller solutions, and consensus must be achieved before action can follow. Through the town meeting, a small number of people can inhibit development. The result is that successful projects tend to break new ground in the details rather than in the overall conception. One can have an ingenious and technically advanced building, containing all sorts of new energy-saving devices, as long as it does not look startlingly different from its neighbor, and as long as it doesn't cost startlingly more than a competitive building without such features.

Central Plains state of the art

David A. Block: The reception that energy-conserving and solar energy architecture has had in Iowa and the near environs has been extremely positive. The agrarian makeup of lowa and lowans car-

Conclusion: Energy-conscious design

ries with it an appreciation for the land and the natural order of things, as well as a sense of human place. These feelings, coupled with the high gamble inherent in farming, have created an environment of "It looks good, I'll give it a try."

The other advantage this region has is low population density which allows more land around buildings and larger lots, even in the cities. We can blend buildings of dissimilar style and soften solar-energy architecture's disparate impact on the environment.

Energy conservation in design now permeates buildings by the majority of the architects in the state. Very little "north glass" is accepted by clients any more without showing some method of covering it in the winter. We have artificially low-priced natural gas for almost all of our buildings, but people just like the idea of energy conservation even though the heating bills are affordable.

Solar architecture is well accepted in principal but not in practice because of the perceived high cost of active systems relative to cheap natural gas.

I expect a very strong regional energy conserving and passive solar style to emerge. It will mate closely with a desire to be a part of the land. Housing will become lower in profile and more and more of it will be built into the ground. Thus I see a dropping of the buildings into the ground and berming up around them for energy-conserving reasons and to bring some interest into an otherwise flat landscape.

I think we will see a significant increase in south glazing and the inclusion of "direct gain" passive systems. Iowans seem to like the sun (probably because it's so cloudy in lowa), and glare seems to be almost welcomed in the winter. Thus I think we will see large expanses of glass opening into very open type living and working spaces just within the building. Because of the availability of land at reasonable prices, this "direct gain" passive with open interiors will look out onto gently rolling or flat Iowa landscapes which will increase the interpenetration of inside and outside space. Also, we will expect an increase in domestic hot-water heating "active collectors" on buildings. This has proven to be the most cost-effective aspect of the solar field in lowa.

In the past five years, the availability of natural gas and its price almost precluded the use of most solar components. Under these circumstances, I often advised clients to build an energy-conserving building now, but make it solar adaptable so that solar equipment could be added in the future. If natural gas is deregulated in our area, the price should rise substan-

tially, and I believe most solar systems will become cost-effective.

A regional characteristic that deserves further mention is vertical glazing for both passive and active space-heating systems. Dr. Laurent Hodges of the Ames Scientific Laboratory and I did a study in which we compared the effectiveness of several collector tilt angles. We included the probability of cloud cover for the winter months and also the probability of snow cover on the ground. Because of the lowangle winter sun and the reflectance off the snow, we found that a 90-degree (vertical) collector is nearly as good in Iowa as a 60-degree tilt (the optimum). Because of the higher angle summer sun, the vertical, or 90-degree, collector is highly favored because it greatly reduces unwanted heat gain. Since sun screens or overhangs can more easily be integrated with vertical glazing, it becomes apparent that both active and passive solar heating systems should have vertical glazing. I think this fact will become an Iowa and Upper Midwest solar trademark.

Pacific Northwest state of the art

John Reynolds: I wish I could report that architects are leading, rather than largely being led by, trends toward conservation. Residential designs are changing more evidently than are commercial ones in the Pacific Northwest. Our clients are asking for conservation, our utilities are offering low-interest (even interest-free) loans for conservation, and our codes are increasingly mandating conservation. Our residential designs now feature less glass (with a higher proportion of it on south façades), less rambling plans, and wood stoves instead of fireplaces. Exposed roof decks are more rare; exposed beams find most of their depth hidden by thicker roof insulation. We are using more gypsum board on ceilings, but less of it on walls. Passive solar techniques are encouraging walls of brick, stone, tile, and concrete block. Floors of brick or quarry tile are growing in popularity. With a more mature utilization of landscape and the unique features brought by renewable energy sources, our Pacific Northwest energyconscious style will come of age. Thick walls and masonry—were it not for our lush vegetation, we might describe present Pacific Northwest residential trends as neo-Southwest!

Our dominant energy form, electricity, is still relatively cheap, but enormous increases are imminent. This will particularly impact residential designs, as winter electric rates are becoming even higher than summer rates.

Designers of commercial buildings will respond to electric rate increases by rediscovering daylight for general lighting, saving electric light for specific task lights.



David A. Block is principal of his own architectural practice in Ames, Ia, and Professor of Architecture at Iowa State U. He is involved in passive solar research for the Engineering Research Institute and the Ames Scientific Lab. Above is the Bowles House, Indianola, Ia, using vertical collectors.

Rodney Wright is president and founder of the Hawkweed Group Ltd., Chicago, II. He is a recent recipient of a National Endowment for the Arts Fellowship for the study of solar usage in existing urban buildings. Shown below is the Findling Residence, New Albany, In.



The dramatic reduction in air conditioning which results will encourage a look at the softer techniques of "passive cooling." Our dry and rarely hot summers, with cool nights followed by days with reasonably dependable breezes, are well-suited to passive-cooling applications.

The thicker walls yield deeper window frames, which serve nicely as mounting surfaces for the variety of architectural "switches," such as thermal shades or shutters, which occupants of buildings can manipulate to tune their buildings to the climate of each day. Such switches will allow a continued, though reduced, use of glass areas (especially on the south) without an excessive night heat loss. Whole rooms will become switches; usable by day when warmed by solar radiation; empty at night if too cool for comfort. Our climate is mild enough that "unheated" rooms, if sunny, can be comfortable for much of the winter.

Architectural switches, then, for both residential and commercial buildings, will become a regional characteristic of considerable richness. Exterior switches can seasonally change a building's appearance, especially when supplemented by deciduous vines for added sun control. Switches lend not only an airy three-dimensionality to our buildings, but also demand a fourth dimension—of change

with time—as well.

Building sizes will change: those with dominant heating needs will cluster and go moderately upward instead of sprawling out. Townhouses or row houses will no longer be rare in the Pacific Northwest. In contrast, commercial buildings will be less monolithic, to allow daylight to supplant electric lights and night cooling to carry away the stored heat of the day. Lower buildings will be further encouraged by solar access legislation, under consideration in Oregon and already the law in California.

In our region, landscaping of lushness and variety is a natural product of long, mild, wet winters and springs. Evergreens are especially characteristic. Here, commercial buildings often benefit from plantings, and residences almost universally surround themselves with vegetation. As we move to solar energy, we will find not only our south façades distinct from other building faces, but south landscaping distinct as well. Evergreens will still be welcome on north, east, and west sides for protection from winter wind and summer morning-evening sun. Our south exterior spaces will be mostly deciduous, with a predominance of early defoliating species: these spaces will act as a sort of reflector to aid the south collector wall in its heating task. Deciduous vines as overhangs will give us south windows that get sun in cool April but shade in hot August.

Midwest state of the art

Rodney Wright: Energy-related considerations are the most important design influence in our work, including climatic data and energy intensiveness of materials. We find little interest in these design inputs on the part of other practitioners in this region.

We would expect more attention to thermal efficiency, expressed in reduced glass area, especially on the north, protection of the building from prevailing winter winds, solar orientation, more compact and smaller buildings. We anticipate increased emphasis on use of regionally available and renewable materials. Solar heating systems will be an integral part of

Energy requirements represent a tremendous opportunity. Use of natural energies in building design is as basic as holding up the roof—or keeping it from leaking. This concept will make architecture honest again. New building forms will now emerge—quiet forms, forms more suited to life, emerging from real needs rather than from manneristic responses to historic architecture.

Thomas Strat: With the sharp escalation of energy cost and the past and possible future regulation of natural fuel in the Northern area, the need to conserve energy for

both heating and air conditioning becomes influential on the building design in terms of massing of volumes, strategic use of materials, sizing, and the placement of fenestration. As one can expect, through use of an analytical approach in design and value engineering, innovation of materials will emerge; thus conservation criteria will be manifest in all visible aspects of architecture. The "marriage" of building and site will become "legal," if not because of good design rationale, then just maybe to be directed by governmental edict, and the landscaping, a conservation tool, will be utilized not for the purpose of embellishment alone.

With the use of solar energy, the "living" or occupied building will be accepted as a source for its own energy needs, thus leading to more efficient use of purchased energy. The concept of shelter will become not only figurative, but literal, in its visible impact on the layman when he can discern for himself how and why a building takes its shape to make most use of its environmental needs.

Southern state of the art

James Lambeth: The temperate region of the Ozark Mountains has traditionally been quite sensitive to energy needs. This is due, in part, to the relatively low per capita income base of the area. Passive solar design has been enthusiastically accepted for its low initial investment and high return on energy savings. Private enterprise has financed the projects with no government assistance required. This unique situation has been a healthy environment for energy-conscious architectural design.

The general trend in the region is to go underground as much as possible. Flatplate collector systems are finding a place in augmenting domestic hot-water requirements. Wood-burning space heating systems are also growing in popularity in the residential market. The southern slopes are being recognized as more efficient building sites by the real estate developers of the region.

Ennis Parker: My observation is that energy has become extremely important as a major design influence all over the nation, and the Southeast seems to be current with the mainstream. In most buildings now under construction or recently completed, energy consciousness is quite obviously present.

In the most recent buildings, the ones either under construction or about to go under construction, the appearance of the buildings has clearly been affected by energy considerations. Such obvious signs as sun screens, reduced fenestration, shaded glass, and in a few cases, major solar installations cannot be missed. I have the feeling, however, that what we can see with the eye thus far may be su-



Gordon F. Tully: Since 1973, as president and cofounder of Massdesign Architects and Planners Inc., Cambridge, Ma, he has guided the firm's energy-conservation and solar work. Shown above is Massdesign's Thompson house in Westford, Ma. Part of Tully's interest is a new computer simulation and solar text. John S. Reynolds is coauthor with McGuinness and Stein of the sixth edition of Mechanical and Electrical Equipment for Buildings. He is profes-

sor and director of the Solar Energy Center, U.

of Oregon, and partner in Equinox Design Inc.



Equinox Design Inc., G.Z. Brown & John S. Reynolds

perficial, and that the impact of energy will be much greater as we learn more and as the economics become clear.

Things not so obvious, such as heavily insulated wall construction, innovative mechanical system design, new concepts in lighting systems, and so forth, are being incorporated to some degree in most major buildings.

Residential architecture is responding very slowly, and in fairly unexciting ways (i.e., increased insulation). In my view, this uninspiring response is a result of the fact that professional designers are generally uninvolved in this sector. Whether this sluggishness will be overcome by new economics remains to be seen.

The fact is that the architecture of the Southeast hasn't had a regional character since the advent of modern building. Houses found here might just as easily be found virtually anywhere (excepting Florida and the coastal regions). So could the office buildings, schools, and major multifamily residential structures.

However, the architecture of the Southeast will be impacted by energy considerations that differ somewhat from those in other parts of the country. It is interesting to speculate whether these factors are of such strength as to impart a truly regional flavor to the architecture of the area. Some factors to consider are:

Conclusion: Energy-conscious design

- 1) The Southeast has a particular problem with peak demands because of extremely high air-conditioning loads in the summer and inefficient peak-demand generating capability. Rate structures are being designed more and more to discourage high peaks in energy demand. The architectural effect can be difficult to discern.
- 2) In the Southeast, the dominant HVAC load is air conditioning. Heat loss can be dealt with via an efficient thermal envelope, but heat gained is more difficult. Here the tendency will be toward less glass, glass oriented first north, second south, only then east and west, and shading of south fenestration.
- 3) Thermal transmission lag is not the factor here that it is in more severe climates, yet we do have short, severe cold spells during the winter. Buildings are consequently likely to be less massive than in the North, but with very extensively insulated skins.
- 4) Solar use, while not as attractive here as in, say, Southern California, is, nevertheless, usable and is likely to be developed further.
- 5) Economizer cycles in mechanical systems are not as helpful as in the North, but are, nevertheless, cost effective and becoming common.

Building forms will change. Orientation and massing will change. The old classic proportions will be discarded in favor of efficiency. Simply hypothesizing with today's experience, I expect to see high-rise buildings tending to be shorter and wider than in the past, in order to gain greatest volume within the least skin area. I expect lightweight, heavily insulated exterior walls with less fenestration than in the past, except on the north façade. I expect buildings to be sited obviously to accomplish energy objectives, and I expect to see a lot of architectural "statements," things obviously done for energy conservation, such as sun shading, intended to reflect the energy consciousness of the designers.

I have a horror of the danger this situation carries with it for architecture and building. The energy question is so prevalent that no owner about to build a new building can ignore it.

In the preoccupation with energy, my fear is that we will fail to remember that buildings are to be used by people, and people have certain needs in addition to low utility bills. I've already seen some pretty scary stuff, windowless and unpleasant, done in the name of energy conservation. I think ultimately that this energy business is likely to have the greatest single effect on architecture, regional or otherwise, since the emergence of the International style.

Energy-conscious design in the future

The authors of this issue have come to many conclusions relevant to the future of energy usage by architecture. Not all of them agree on the methods to achieve energy conservation but all of them expect a great future for energy-conscious architecture. We have isolated 10 conclusions below which we believe offer a profound stimulus to your creativity.

- 1) Architects have played a leading role in the creation of the Building Energy Performance Standards. A bright energy future for architecture is directly dependent upon maintaining that leading role. Such leadership will also require an increase in cooperation between the architectural and engineering professions. The new breed of architect speaks the language of the engineer. A new breed of engineer will be expected to program as well as design and size HVAC elements.
- 2) The effect of solar access and growing energy independence of buildings will be a gradual restructuring of planning principles and the resulting planning patterns in existing communities. New community planning will have the opportunity for innovation in this field.
- 3) Construction, operation, and maintenance energy costs will ripple through the decision-making process from top to bottom. The decision to build new buildings or revitalize the old will be subject to a new economic equation. Energy consciousness helps to build a case for more lasting, adaptable buildings.
- 4) The aerodynamic principles and thermodynamic role of wind and air movement will introduce a new body of design information which is bound to inspire new solutions from planners, and landscape architects as well as architects. Buildings will be sited, shaped, and fenestrated to optimize wind benefits.
- 5) As experience and confidence grow in the modern use of underground and earth-related energy conservation, new ways will be devised to increase its economic viability and profit from its forms.
- 6) Energy consciousness can have a profound influence on the envelope of the building. The texture and color of the building surfaces exposed to sun, wind, snow, rain, and dust need reexamination. Textural surfaces whose thin air film is more stable in wind will be sought in areas of high-wind energy loss. The color of roofs, walls, and soffits (both outside and inside the building) will become more sensitive to the reflection and absorption of light and heat. Buildings can be designed with wind breaks and sun shields, as well as scoops and stacks for wind and sun. There will be new opportunities for multiple glazing and thermal shutters. Window, skylight, and door designs will reflect the concern for reducing undesirable air infiltration, con-

trolling heat exchange, and profiting front natural ventilation and lighting.

7) Building planning and organization require a new sensitivity to machine location and mechanical space. Ducts can enlarged, air velocity reduced, and rur shortened to help reduce energy usag Pumps, fans, and other building equipment will seek energy conservation fro combinations of continually running equipment rather than larger units designed to accommodate infrequent heavier loads. Watch for more heat pumps, Rankine cycle engines, and in creased use of economizer cycles.

As ducts and pipes become more fr quent visual elements in the space, en will also dominate decisions on structu height. Building volume and surface a must demonstrate a clear match to the function it serves.

- 8) The reconsideration of activity-relating ting demands will continue to offer opportunities. More attention will be part to adaptability, artificial and natural ligit rade-offs, high intensity discharge light sources, and lighting control and main nance characteristics.
- 9) As energy performance criteria cortinue to tighten, building owners and occupants will become more sensitive operational control. For large- and medium-scale projects, central control systems will become invaluable, and centralized computer control more communismall buildings, architects will need think out operational procedures which encourage intelligent energy usage, covenience, and efficiency.
- 10) As the research into the merits of passive solar design continues, confidence in the various design methods of grow and passive considerations will be come standard elements of the archite tural design vocabulary. As convention fuel prices escalate, and tax advantagement, we can expect an increase in the use of active solar collectors for hot-washeating throughout the country. As the standards for manufacture, shipping, installation improve, we look to the increased use of low-temperature collect to supplement small-scale heating methods.

In conclusion

The most powerful tools in America for conserving energy in buildings today a research, knowledge, and ingenuity. T issue of *Progressive Architecture* has a been about buildings. It has, we hope, been an exploration of ideas and an induction to people. It puts you in touch a set of people throughout the country today who are thinking, designing, or manufacturing with energy in mind. The best we can do is cause you to get together with them. [Richard Rush]



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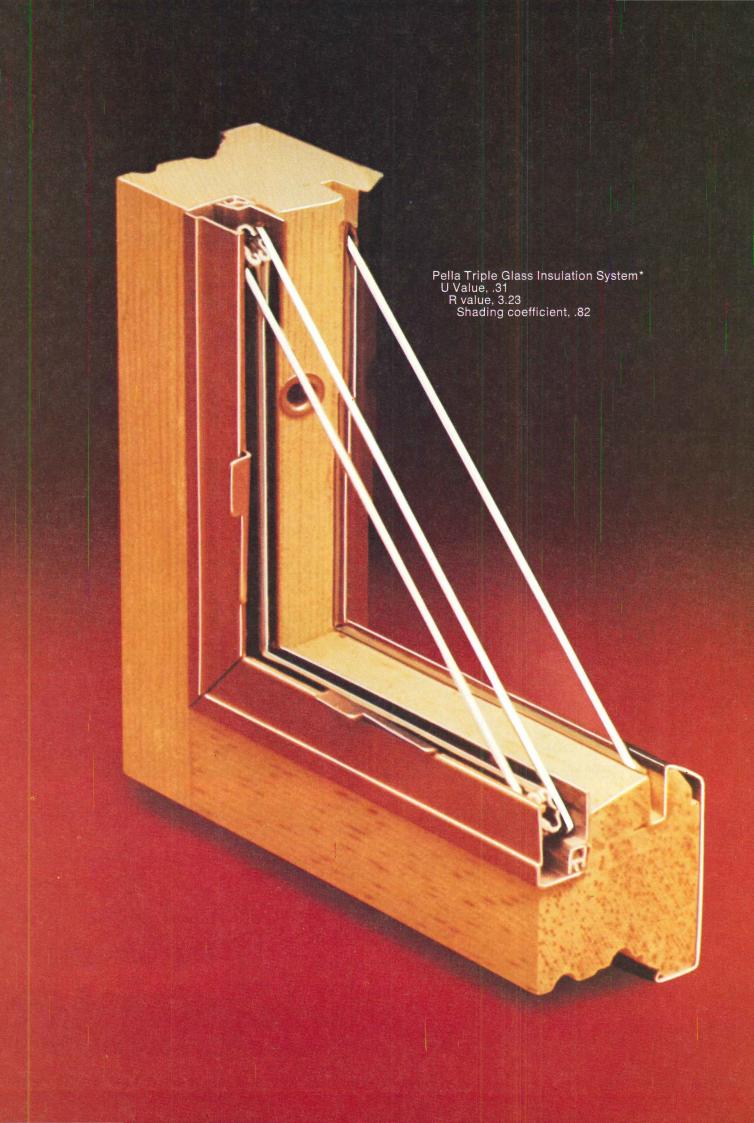
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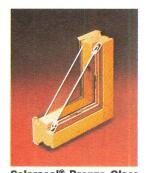
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Selected energy bibliography

Chris Johnson



The range of books on energy-conscious design is immense, considering that most of them have been published only within the last five years. In this bibliography, over 300 titles were initially screened, but due to obvious limitations only 25 have been selected for brief review here, with attempt to be as broad as possible and to provide, in a sense, a "starter kit."

The books available have generally concentrated on small-scale projects of interest to home designers, or have dealt with in-depth studies of technical issues written for engineers or researchers. Very few have approached the area of nonresidential buildings, or have provided usable information or solid reference material that could allow the harried architect to make decisions quickly and intuitively, but that would also provide in-depth coverage for later substantiation.

Most of the books reviewed approach energy as a technical subject and rationalize energy-conscious design through the savings of energy or money. But for energy consciousness to become a truly significant part of the design process, it must move beyond such a narrow view. The architect, like many professionals, seeks the interplay between man's rational considerations and humanistic needs that results in successful design, where the unnatural conflict between technology and art has been resolved. Although consideration of this conflict is beyond the scope of this review, it has been the subject of many books, including Stepping Stones: Appropriate Technology and Beyond by DeMoll and Coe; A Pattern Language: Towns, Buildings, Construction by Alexander, Ishikawa, and Silverstein; and Zen and the Art of Motorcycle Maintenance by Pirsig.

Application of Solar Technology to Today's Energy Needs. 052-003-00539-5. Office of Technology Assessment, Government Printing Office, Washington, DC, 1978, illus., 525 pp., \$7.

The federal government has provided an essential service through this book. The volume outlines the five- to ten-year near-term feasibility of solar energy in on-site applications. All architectural and building uses of solar energy are included. Although this is not a design manual, it is, however, one of the best "state-of-the-art" volumes available. Included is an overview of the existing technology, including on-site electric power generation, tracking, nontracking, flat-plate and concentrating collectors, heat engines, energy storage, and heating and cooling equipment. The book has an excellent, easy to follow description of photovoltaics (passive solar electric power generation), their manufacture, and potential. A summary of the present and future economics of solar use is included, where its cost is compared in different applications to the currently available fuels and future

prices. Other sections include an excellent review of possible federal policies for promoting and regulating solar energy, the relationship of on-site solar with public utilities, impact of solar on foreign policy, labor, and environmental quality. The book is less an idea manual than a realistic assessment of the present and future of solar energy.

Architecture and Energy by Richard A. Stein. Anchor Press, N.Y., 1977, illus., 322 pp., \$12.95.

GTRMS

Architect Richard Stein, an early proponent of energy-conscious design, has produced an admirable book for the architect and the lay reader that is not a how-to-do-it manual, but rather a means for the reader to become aware of the enormous amounts of invisible energy used by our buildings. A feeling of impending doom underlies this writing, some of the best of which outlines the little-researched area of energy in materials and construction. Stein illustrates the need to consider not only the energy consumption of a building after construction, but the energy of construction, manufacturing of materials, and the eventual demolition of the building. He has provided one of the few writings on energy and the implications of aesthetics and architectural style, and traces historical examples to show the slow abdication of architects from the technical areas now performed by engineers and consultants. Throughout, he continually insists on comprehensive planning processes.

ASHRAE Handbook and Product Directory, 1977 Fundamentals. *American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.*, 1977, Illus., 760 pp., \$40.

GTRNS

For an architect to be truly energy-conscious, this authoritative handbook is a required reference, as it is the accepted industry standard for the majority of the thermal energy calculations. Especially useful are sections explaining how to quantify the flow of energy in a building during the heating and cooling seasons, and the detailed discussions on shading, air movement, thermal properties of materials, and pipe and duct sizing. The handbook can be quite technical and in some sections extremely difficult reading for the architect, so a basic understanding of the thermal properties of buildings is highly recommended before plunging into it. Almost every piece of information presented has been thoroughly studied by industry experts and documented by research. The handbook is a companion to three other volumes-Applications, Equipment, and Systems—which each year, in rotating order, are updated, usually with considerable changes. [Books continued on page 158]

YOUR FIRST OLAR JOB

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It can be lonely, that first solar job. For in addition to energy, the sun radiates a whole new set of variables for the architect and engineer - collector tilts and orientation, row spacings, storage sizing, life-cycle costing. Definitely not your typical HVAC

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Control Systems for Heating, Ventilating and Air Conditioning, 2nd Edition, by Roger W. Haines. Van Nostrand Reinhold, 1977, illus., 233 pp., \$7.

GTRNS

The control of a mechanical system, although small in physical dimension, can be one of the major causes of excess energy use in a building. This text offers an excellent general understanding of controls and their interface with common commercial mechanical systems. The book is directed primarily to engineers and technicians, but can be of interest to the architect working extensively in energy conservation or solar energy. It explains the operation of three types of control—pneumatic, electric and electronic, and fluidic—and through this also clearly outlines the different kinds of mechanical systems and possible design implications. One of the most useful chapters introduces sophisticated supervisory systems now being used to control the scattered mechanical components of a building from a central computerized point. The writing style is clear and there are ample good graphics to help explain the concepts.

Design with Climate by Victor Olgyay, Princeton University Press, Princeton, NJ, 1963, illus., 190 pp., \$30.

GTR NRS

A classic on energy and buildings, this book written in the early 1960s still presents very useful information. Included are the effects of regional climate on man and his buildings and its interpretation into architectural design principles. Major emphasis is given to site selection, solar control, environmental and building forms, wind effects and air flow patterns, and the thermal effects of materials. The single largest omission from the book is the effect of internal building heat from people and equipment and its modification of the thermal performance of a building, especially nonresidential structures. The book assumes most buildings are affected primarily by climate, but with today's tightly insulated and sealed nonresidential buildings, this is often no longer the case, as today's buildings and mechanical systems must, in many instances, respond to the internally generated thermal loads. Although the book was written long before energy-conscious design became increasingly practical, it is an important work for environmentally thermal-loaded buildings.

Designing and Building a Solar House: Your Place in the Sun by Don Watson. Garden Way, Charlotte, Vt, 1977, illus., 272 pp., cloth, \$12.95; paper, \$8.95.

GTR NRS

Since solar homes have captured the imagination of the people of the U.S., many book publishers have prepared a "solar book for homes." The publisher of this one can be extremely proud, as it is one of the top contenders for being the best. In his typical, meticulous style, Watson covers the solar home field completely, using good photographs, drawings, and charts to describe in detail active and passive systems. A very strong point is his thorough explanation, along with superb isometric drawings, of the interface between solar and backup systems for the home—an often neglected subject that is really the heart of a successful system. An appendix shows a simplified solar design calculation procedure which, without a check of its accuracy, seems complete and well organized.

DOE Facilities Solar Handbook, 061-000-00097-6. U.S. Department of Energy, Government Printing Office, Washington, DC 1977, illus., 169 pp., \$3.75.

GTR MS

This handbook, prepared by Bruce Hunn and Doug Balcomb, is intended for the design of solar heating systems for the Depart-

ment of Energy's commercial and laboratory buildings. It is one of the few works to focus on commercial size structures, and therefore is one of the most useful to the architect. Because the difficulty of designing for energy conservation in many cases lies in the actual calculation of the building's thermal performance, this book's section explaining the Bin Method of determining yearly performance is very useful. This hand calculation method is one of the best compromises between the simple Heating Degree Method, which is much too inaccurate for nonresidential structures, and extensive and costly computer modeling which is usually out of the question. The Bin technique can also be modified to calculate cooling or other types of mechanical requirements. Bin data, which is the number of hours a given temperature occurs, is given for 16 locations in this manual. Data for other locations are available in Air Force Manual 88-29 Engineering Weather Data: Facility Design and Planning (information on availability can be obtained from the Chief of the Magazine and Book Division, AFSINC, Kelly AFB, Tx 78241).

Energy, AIA Energy Notebook. AIA, Washington, DC, 1975–1978, illus., three volumes; \$95 annually to AIA members, \$120 to others.

GTRN35

The AIA provides this admirable publication at an alpine annual renewal. The notebook, in the format of three large yellow volumes using three-ring binders, permits the inclusion of quarterly updates and superb monthly newsletters. Some of its unique features include a regulation section that surveys the existing federal and state legislation about tax credit rebates, codes, and standards; and a reference chapter with a thorough review of over 175 energy-related books. Also included are case studies of respectable, built commercial and residential energy-conscious design projects. The notebook got off to a slow start in 1975, but it has been gaining momentum and is truly worthy of wider readership, promising as it does an ever-higher quality product during the coming years.

Energy and Form: An Ecological Approach to Urban Growth by Ralph L. Knowles. MIT Press, Cambridge, Ma, 1974, illus., 198 pp., paper, \$7.95.

STRNS

"In the extreme southwestern corner of Colorado lies a deeply eroded tableland called Mesa Verde. Within this region is a large south-facing shallow cave in which the Indians have built one of the finest structures for efficient use of the daily and seasonal rhythms of the sun." The description by Ralph Knowles of the Mesa Verde solar structures, along with those of Acoma and Pueblo Bonito, have become classics in how the ancient Americans used the sun. Using the techniques developed for analyzing these old structures, he develops some absorbing theories for the design of today's structures. The writing style is very dense, with sentences full of thought. Careful reading and rereading, however, will reveal concepts of design of use for any project, whether the major emphasis is on energy or not. The book is a wonderful beginning for understanding how the sun and wind can be used in the design of the larger community structures which can be both energy efficient and beautiful.

Energy Audit Workbooks. Department of Energy, Assistant Secretary for Conservation and Solar Applications, Office of State and Local Programs, Office of State Grant Programs, Washington, DC 20461, 1978, illus., 11 volumes, \$6.00 to \$6.50 each.

GTRMS

Energy audits can become a revenue source for an architectural firm, and a method of promoting its architectural capabilities for future design projects. The audits have become increasingly important, now that money is being provided by the recently [Books continued on page 161]

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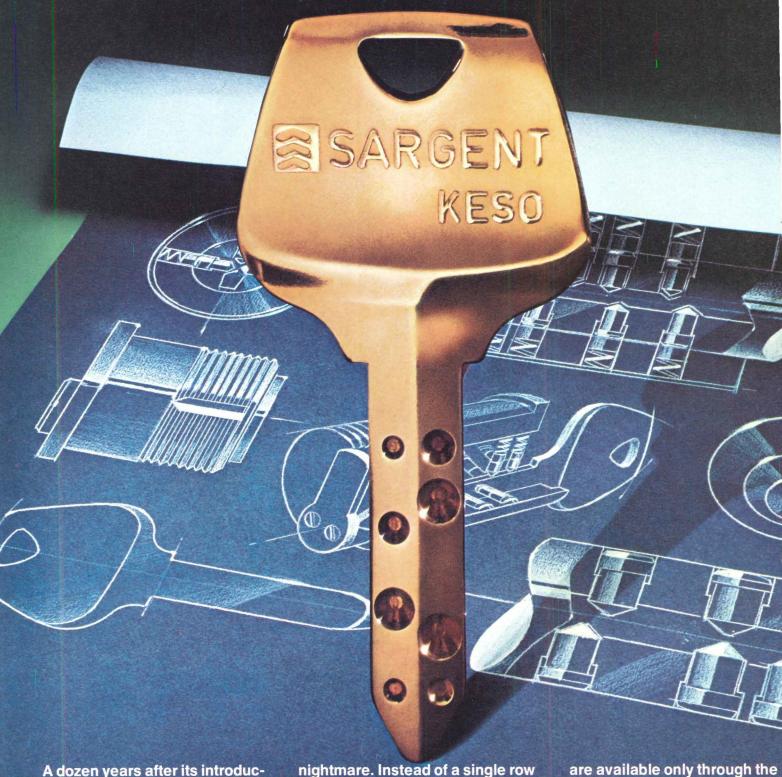
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Books continued from page 158

passed National Energy Act, which provides funds to each state for audits on residences, schools, hospitals, and public buildings. These workbooks for 11 different types of buildings (bakeries, diecast plants, educational institutions, hospitals, hotels and motels, offices, restaurants, retail stores, transportation terminals, and warehouses and storage facilities) are very simply written, with the valuable contribution of simple sample problems for the given building type. Although primarily for the nontechnically trained, they provide an initial understanding of audits, but should be used with other, more technical manuals.

Energy Conservation in Buildings: Techniques in Economic Design by C. W. Griffin. Construction Specifications Institute,
Washington, DC, 1974, illus., 183 pp., \$20.

STRMS

This is one of the best early manuals written after energyconsciousness became an important design parameter, and it is still one of the few commonly available books on non-residential applications. It explains energy-conserving mechanical and architectural design principles, stressing the economics of energy conservation with chapters on financial obstacles to energy conservation, operating and maintenance economics, and life-cycle cost techniques. The manual is minimal in the discussion of architectural design concepts, but covers the basics of thermal insulation and glass-wall design, Mechanical concepts and systems are covered, with a special emphasis on waste-heat recovery, system controls, lighting and electrical design, and solar energy. A case study on a six-story GSA demonstration project is included. The book is an excellent manual for the explanation of general concepts of energy conservation, but it should be backed up with more recent technical information on particular subjects.

Energy Conservation Standards for Building Design, Construction and Operation by Fred S. Dubin and Chalmers A. Long, Jr. McGraw-Hill Book Company, NY, 1978, illus., 413 pp., \$22.50.

GTR MS

The integration of the mechanical and architectural concerns can be difficult, but one man who comes close to understanding both fields is Fred Dubin, a practicing professional engineer with a recently acquired Master of Architecture Degree. Along with Chalmers A. Long, Jr., and an extensive backlog of research paid for by the federal government, a truly outstanding book has resulted that is full of well-presented, quantifiable advice for the design of energy-conscious buildings. It is must reading for every architect, and mechanical and electrical engineer. The unfortunate title can be misleading, as it implies a boring text on legislative codes and standards. But nothing could be further from the truth; the book is a delineation of design concepts rather than rigid standards. The pages are filled with easily understood graphics, nomographs, and rules of thumb in the book's coverage of heating, ventilating, and air conditioning, lighting and electrical, along with alternate energy sources for new and existing buildings. The ideas presented are practical, and the manual is very appropriate for most architectural firms in providing information on the type of building architects design the most—nonresidential. Ten minutes of reading will easily yield an idea worthy of the book's cost.

Earth Sheltered Housing Design: Guidelines, Examples and References. Underground Space Center, University of Minnesota, Minneapolis, 1978, illus., 310 pp., \$11.

GTRNS

[Books continued on page 162]

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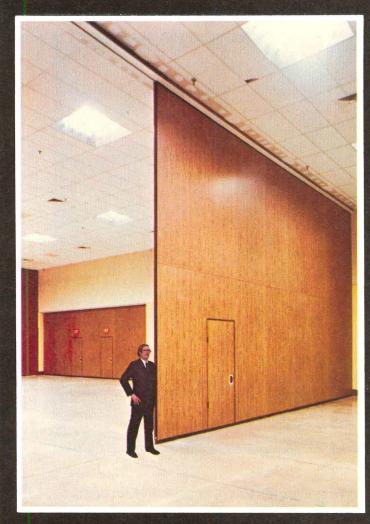
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Books continued from page 161

This outstanding work on underground housing contains valuable information for the homeowner, designer, and engineer. Funded by the Legislative Commission on Minnesota resources, the book covers all of the major issues of designing an earth-sheltered house, including architectural and structural design, energy use, waterproofing and insulation, with examples of existing structures in both cold and warm climates. The appendix contains an extensive reference list as well as technical data on energy calculations. This is the one book to have on underground houses.

The First Passive Solar Home Awards. Division of Energy Building Technology and Standards, Office of Policy Development and Research, U.S. Department of Housing and Urban Development, Washington, DC, 1979, illus., 226 pp., free.

STR NRS

During the summer of 1978, the federal government sponsored a competition for the design and possible construction of solar passive homes. Of the 550 submissions, 162 were selected for awards, including 145 for new homes and 17 for retrofit installation of passive solar elements on existing homes. With this recently released manual, the government has provided a valuable service by quickly assembling a review of the design projects into a fine publication. All of the projects are small, and the information provided pertains mostly to residential architects and builders. The 145 homes are classified into direct gain, indirect gain, and solarium types with a few of the best examples given an in-depth written and graphic description. The rest are given a half-page summary, but an illustration of each is included. Some of the best information is in the concluding chapters, which include the most common thermal mistakes noticed during the review of the projects, typical construction details, and an example of energy calculations. The book is given a fanciful lift at the end with a funny, but well designed, solar-passive doghouse.

Landscape Planning for Energy Conservation, edited by Gary O. Robinette. U.S. Department of Housing and Urban Development, Environmental Design Press, Reston, Va, 1977, illus., 224 pp., \$20.

GTRNS

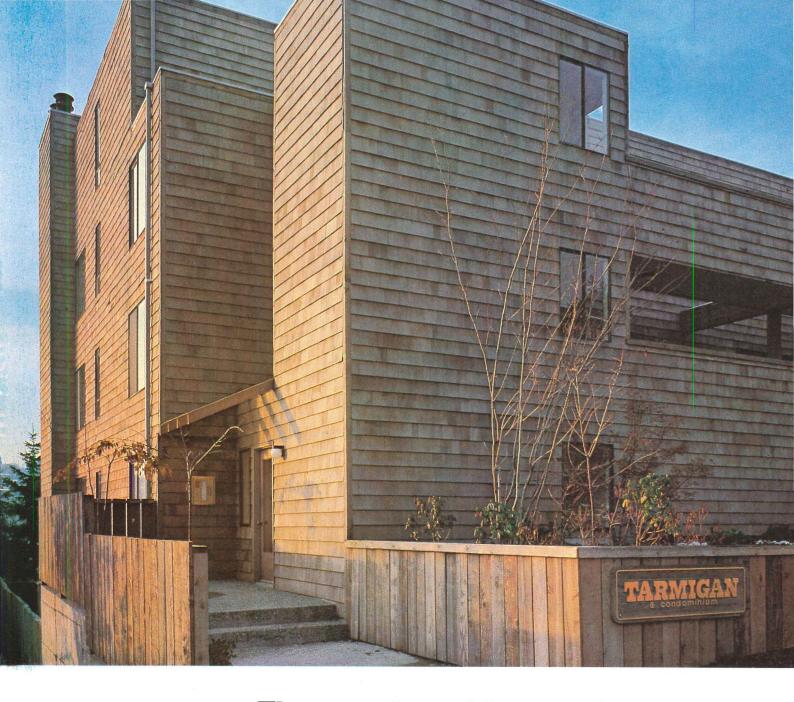
An excellent compilation presents the papers of six respected landscape architects and provides an overview of site planning process with special emphasis on energy planning issues. As with most books by a team of writers, it tends to be a little choppy in writing and graphic styles, and for the most part the information presented is not original but cut and pasted from other sources. Although not intended primarily for architects, its methodology on the integration of landscape principles into architectural planning process is a welcome addition. The book is a good first step toward developing truly innovative landscape concepts.

Natural Solar Architecture: A Passive Primer by David Wright. Van Nostrand Reinhold Company, NY, 1978, illus., 245 pp., \$14.95 cloth; \$7.95 paper.

STR NRS

David Wright built some of the good early examples of solar responsive homes in New Mexico and California, and at a young age is a respected leader of passive design. This book is a comprehensive idea source for the uninitiated in the principles of designing a solar home. One of its best sections, however, is on the often-overlooked question, passive cooling, which gives a quick overview of night air cooling, skytherm roofs, shade roofs, cool courtyards, earth burrowing, microclimate control evaporation, [Books continued on page 167]





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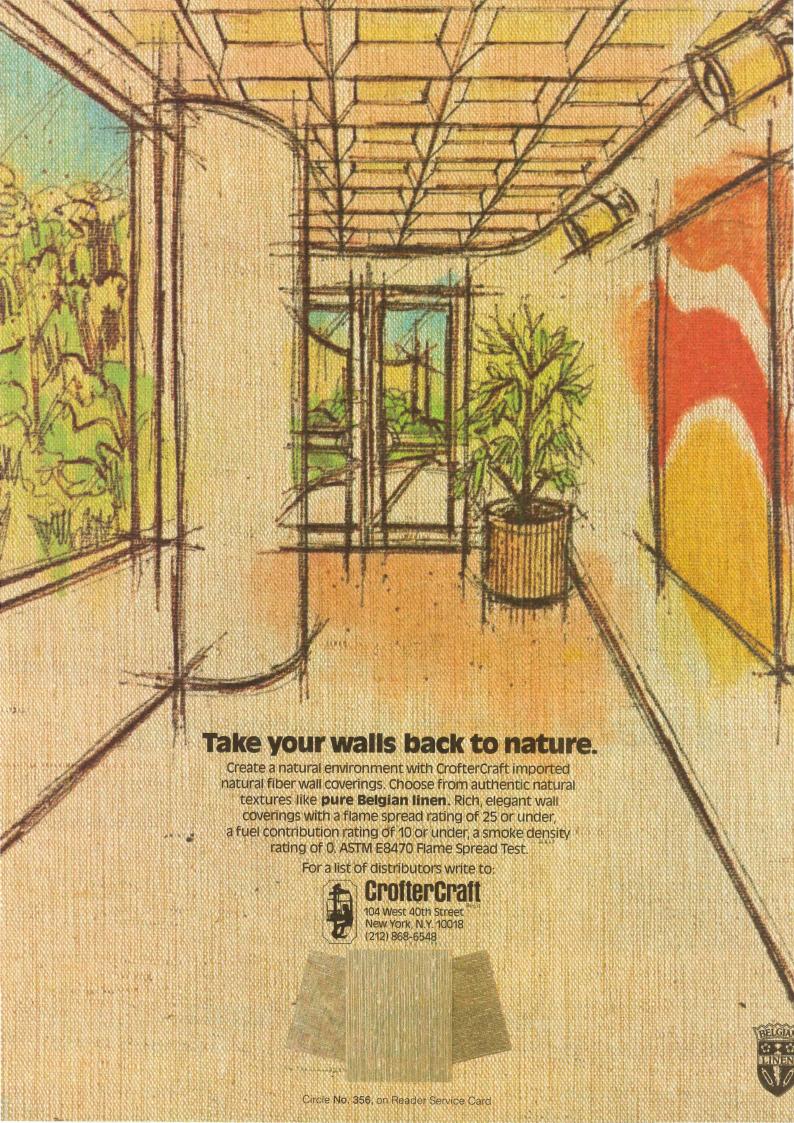
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Books continued from page 162

black tents, earth tubes, cooling towers, ice walls, and dew ponds. The book is primarily for ideas, and offers little in the way of built practical examples.

Other Homes and Garbage: Designs for Self-Sufficient Living by Leckie, Masters, Whitehouse, Young. Sierra Club Books, San Francisco, Ca, 1975, illus., 302 pp., \$9.95 (members, \$7.95).

GTR NRS

The concern for energy conservation had its beginnings with the environmental movement of the late 1960s, when energy was thought to be the thread tying the biological, technological, and human lifestyles together. Therefore, the early books on the subject tended to view energy as a systems problem requiring the input from many divergent disciplines. Although published later, this book is one of the best of that type. It includes fine introductory material on architectural design, the small-scale generation of electricity (wind and water), solar heating, waste-handling systems, water supply, and agriculture and aquaculture. The information presented is technical but easily read and with excellent backup diagrams and drawings.

The Passive Solar Energy Book by Edward Mazria. Rodale Press, Emmaus, Pa, 1979, illus., 460 pp., \$12.95.

GTRNRS

This book comes in a trade and a professional edition, and it is the latter that will become for the architect the best source for Passive Design principles. The main body of the book is organized around 27 concepts, or patterns, for the application of solar energy systems to building design. These patterns are sequenced from large to small scale and are cross referenced. Typical titles for patterns include: solar window, masonry heat storage, movable insulation, and summer cooling. With each pattern, there is a clear and consistent format: a photograph, a statement about the pattern, a specific rule-of-thumb recommendation, and a clarifying diagram. This logical format allows the reader to quickly scan through the patterns and locate the techniques of design most appropriate for his individual problem.

Planning and Building the Minimum Energy Dwelling by Burt, Hill, Kosar, Rittelmann, edited by Kirk Williams. Craftsman Book Company, Solana Beach, Ca, 1977, illus., 287 pp., \$10.

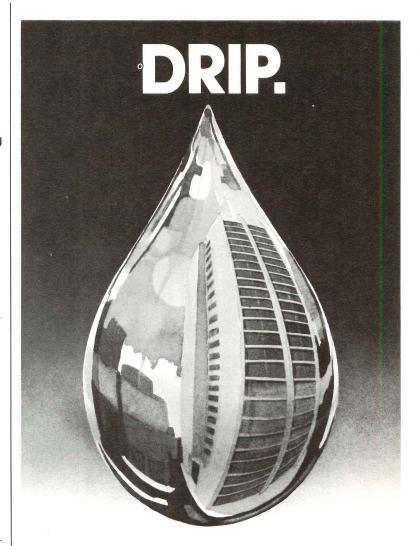
GTRNRS

This excellent, comprehensive approach to the design of a home attempts to deal with many planning issues, from community planning to construction problems, and this may be its greatest strength or weakness, since highly technical information is integrated into a text with other, more general concepts. The book has some fine chapters, including those on comfort and climate, community planning, residential energy usage, thermal mass, water-saving fixtures, and construction, and it also provides a useful matrix on the major types of insulation. The research for this book received a Progressive Architecture Award in 1977.

Rainbook by the editors of Rain Magazine, Schocken Books, NY, 1977, illus., 251 pp., \$7.95 paper, \$15 cloth.

GTRNAS

The reduction of energy use in society will involve many disciplines and the slow evolution of a new lifestyle. *Rainbook* is a splendid, superbly illustrated resource that shares "methods, projects, books, and ideas from around the country and abroad, and is dedicated to decreasing wastefulness while improving the quality of daily life." In many ways it is an updated *Whole Earth Catalog*, including sections on economics, community building, communications, transportation, shelter, agriculture, health, [Books continued on page 169]



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PA-49

Books continued from page 167

waste recycling, and energy. The discussion of energy is clear and very complete, covering aspects from the global and national implications of energy to the generation of renewable energy through solar means, wood, bioconversion, and wind.

Solar Control and Shading Devices by Olgyay and Olgyay. Princeton University Press, Princeton, NJ, 1957, 201 pp., \$20.

GTR MS

During the 1950s tremendous interest and study was devoted to the use of glazing and the environmental implications of sun and wind. However, as relatively inexpensive mechanical air conditioning became widely available, the fascination waned, but during that brief period the Olgyay brothers prepared this old and useful book on exterior shading concepts. Prepared for the architect, the work includes numerous photographs and graphics with easily understandable charts, and it is divided into four parts: theory, technical considerations, practical applications, and architectural examples. The last portion is most valuable, showing 64 examples of buildings with exterior shading. Many of these are by renowned architects, such as Niemeyer, Rudolph, LeCorbusier, and Neutra, whose ideas are still quite relevant now in the emergence of Post-Modern design principles.

The Solar Decision Book: Your Guide to Making a Sound Investment by Richard H. Montgomery. John Wiley and Son, NY, 1979, illus., 305 pp., \$10.

GTR NRS

The title is appropriate for this book, which takes the unknowledgeable reader through the step-by-step decision-making process of obtaining a successful solar collector system. Clear definition of methodology, good illustrations and line drawings, clear and simple charts and graphs help to make the work unique among the multitudes of solar books. It is most appropriate as an introduction for installation people going into the residential solar heating field, but can also be useful in fulfilling the needs of many architects and homeowners. The book has minimal text on domestic hot water heating and cooling systems, and shows little concerning the design of passive solar residences. Some unusual features for a book of this type are included, such as advice on obtaining a loan, methods of installation, maintenance, cost of fuel and its escalation and pricing. Highly recommended as an introduction to the solar home heating system.

The Solar Home Book: Heating, Cooling and Designing with the Sun by Bruce Anderson with Michael Riordan. Cheshire Books, Harrisville, NH, 1976, illus., 297 pp., \$8.50.

GTRNRS

This excellent introduction to using radiant energy of the sun, either through the use of solar collector panels or the design of the home itself, is unusual in its focus on both active and passive systems. The emphasis is decidedly residential, but the book would serve as a superb introduction for the homeowner, builder, tradesperson, designer, and architect. The carefully edited text has very little technical jargon to stumble the lay reader, and any necessary technical writing has been diligently kept in the side margins for slower, more careful reading. Another book by Bruce Anderson, Solar Energy: Fundamentals in Building Design (McGraw Hill Book Company, \$23.95) is more technical, but both can be recommended to the architect.

Sun Earth: How to Use Solar and Climatic Energies by Richard L. Crowther. Charles Scribner's Sons, NY, 1977, illus., 232 pp., \$12.95.

GTRMS

[Books continued on page 170]

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NSF has been engaged in the development of standards, education programs and research related to alternative wastewater systems and has sponsored five annual conferences on onsite wastewater systems.

For economic and technical information about onsite alternatives call or write Dr. Nina I. McClelland at NSF.



National Sanitation Foundation—an independent non profit, non governmental organization dedicated to environmental quality. Offices and laboratories: NSF Building, Ann Arbor, Mich. 48105 (313)-769-8010

Circle No. 379, on Reader Service Card

Books continued from page 169

This book by an innovative architect is a basic primer on energy and architecture, and makes excellent general reading. Included are the principles of design when using the sun, wind, and water, and also a quick historical and contemporary description of the use of energy. Toward the back of the book, case studies of the author's own projects are included, with good descriptions of his design philosophy. Very good graphics further recommend this work as an introduction to those needing an excellent foundation on energy-conscious design for residential and commercial structures.

Window Design Strategies to Conserve Energy, 003-003-01794-9, U.S. Department of Commerce, National Bureau of Standards, Government Printing Office, Washington, DC, 1977, illus., 205 pp., \$3.75.

GTR MS

Although not a beautiful book in page layout or graphics, this fine document is filled with useful material for the practicing architect. In its treatment of potential thermal improvements of glazing, 33 strategies were investigated under six main subdivisions: site, exterior shading, frame, glazing, interior accessories, and building interior. Each strategy is described technically and documented in a clear and consistent format showing its potential advantages and disadvantages. The more intangible characteristics of aesthetics and cost are given a short discussion along with one example or case study. The guidebook can be most useful in the early design phases of a project when the exterior shell of a building is being conceptualized and detailed information is not required. For its price, you can't beat it.



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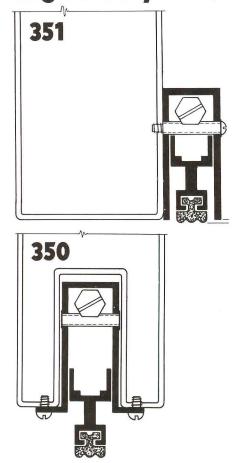
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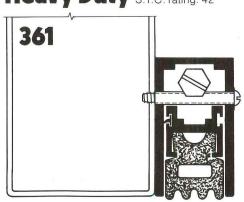
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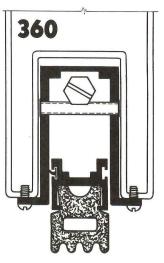
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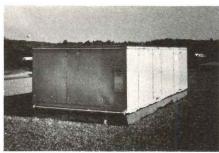
AAF taught Pineview Elementary School a valuable lesson:



how to keep old and new classrooms comfortable with just one energy-efficient HVAC system.

Officials at Pineview Elementary School in New Albany, Indiana were faced with tripling the size of the existing building to accommodate a rapidly increasing school population . . . a project that involved major renovation and new construction.

When it came time to select an HVAC system, a water-source heat pump arrangement was recommended because it could offer operating economy and design flexibility. However, it couldn't be just any heat pump system. It



For Pineview's large multipurpose room, the reverse-cycle EnerCon roof-mounted unit was specified. It offers maximum efficiency for heating and cooling large open areas.

had to be compatible with the present physical plant, provide temperature control throughout both structures, and substantially reduce operation costs.

The new system had to be flexible too, because perimeter and interior areas—large and small—had to be served simultaneously. And, in keeping with cost saving measures, the new system had to incorporate the existing boiler and outside air louvers.

For these reasons, AAF was selected. It has a water-source heat pump system that's so flexible, it could meet all these heating/cooling needs. That system is EnerCon.®

Perimeter classrooms were served by RC UNIvents with 100% O.A. capability, interior classrooms and corridors used horizontal concealed models; the media center relied on vertical units, and a large multi-purpose room was heated/cooled by a roof mounted EnerCon unit. Console EnerCon units were used in the administrative area and in small interior classrooms.

EnerCon is an energy-saving system that consists of a series of unitary water-



EnerCon unit ventilators heat and cool all perimeter classrooms at Pineview. They utilize 100% outside air for "Natural" cooling and meet state ventilation codes.

to-air heat pumps connected to a central water loop. This highly dependable water loop absorbs, stores, and redistributes heat so effectively that EnerCon can operate up to 25% more efficiently than most systems currently used in many schools.

For more information, contact your nearest AAF representative. Or write: American Air Filter Co., Inc., Dept.268, 215 Central Avenue, Louisville, Kentucky 40277.

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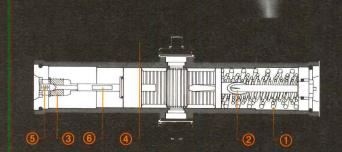
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Specifying for energy conservation

William T. Lohmann

Mandatory energy conservation standards are already having an effect on the way in which specifications are written.

With many state energy codes now in effect and passage of Public Law 94-385 considered likely in the near future, energy conservation is here to stay. Architects and engineers are starting to look twice at responsive siting of buildings for sun control and winter protection. They are minimizing exterior exposures, sometimes going underground. The environmental effects of glass and other basic materials are being reevaluated. Contractors are looking for energy-saving construction techniques, summer scheduling, and efficient use of cranes and other high-consumption equipment. The ultimate impact of energy awareness on the construction industry will be great.

For the specifier, several factors involved in selecting and specifying familiar products assume greater relative importance when energy conservation becomes a consideration. Some materials are energy-intensive in their manufacture, such as aluminum, kiln-fired masonry units, and plastics. Many require energy-intensive installation and maintenance. Certain performance characteristics become critical. Some products obviously last longer than others. More exacting workmanship requirements, even for common products, can effectively reduce energy consumption.

Such factors affect the specification of familiar materials in most CSI divisions. Consider the following:

Division 2—Site work. More stringent requirements for granular fill and drainage system at below grade walls. Foundation insulation. Retention ponds.

Division 3—Concrete. Proper use of permanent insulating formboards. Testing requirements for thermal conductance of poured gypsum and lightweight concrete decks. High early strength cements.

Division 4—Masonry. Clean cavity walls. High-strength mortars. **Division 7—Thermal and moisture protection.** R-values for insulation materials. U-values for wall assemblies. Additional thermal insulation value of fireproofing and acoustical materials. Proper venting of roofing, attics, and enclosed soffits. Critical requirements for preparation of joints and application of appropriate high-performance sealants. Tight vapor barriers.

Division 8—Doors and windows. Insulated exterior metal doors and frames. Effective weatherstripping and seals at sills. Thermal break design for storefront and window wall members. Adequate door closers and latching hardware. Stringent infiltration requirements for windows. Double or triple glazing in operable windows and exterior doors.

Division 9—Finishes. Thermal insulation value of interior finish materials, such as carpeting on exterior walls, acoustical ceiling systems, and flooring above crawl space. Energy costs of required maintenance procedures.

Division 10—Specialties and Division 11—Equipment.Nonelectrical items where possible (flagpoles, signs, equipment). Blinds and other sun-control devices. Recirculating fire-places.

Division 13—Special construction. Wind and solar energy systems

Division 15—Mechanical. Solar implementation piping and equipment. Heat recovery units. Hot and cold fluid storage tanks. Water recycling systems.

Division 16—Electrical. Off-peak motor control systems. Efficient luminaires for range of acceptable lighting levels. Selective switching for lighting. Photovoltaic conversion plates.

New products developed to meet the changing energy picture may present more of a problem to specifiers. For materials such as solar heat transfer fluids and shading films, reference standards may not be available or may come from unfamiliar sources such as NASA or the Department of Energy. Historical evidence of prior performance will be nonexistent.

Some new building products will demand complete performance specifications and have a marked effect on other components. Consider the following requirements for a solar collector panel:

- 1 Normal and maximum operating temperature ranges, including maximum stagnation temperature and maximum allowable temperature for collector coating.
- 2 Absorptivity of short wave radiation and emissivity for long wave radiation.
- 3 Thermal and mechanical performance of glazing.
- **4** Allowable pressure drops and higher operating temperatures for related piping.
- 5 Improved corrosion control and protection against freezing.
- 6 Critical testing and balancing of the fluid system.

Interestingly enough, a moral concern for energy conservation is perhaps more basic, and more immediately implementable, than the confusion of codes and legislative guidelines presently on the books. We owe it to ourselves to do what we can. \square

Author: William T. Lohmann, AIA, FCSI, is Chief Specifier for C.F. Murphy Associates, Chicago, Illinois.

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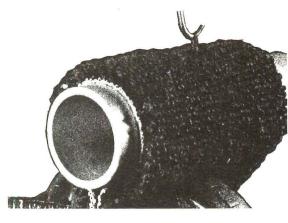
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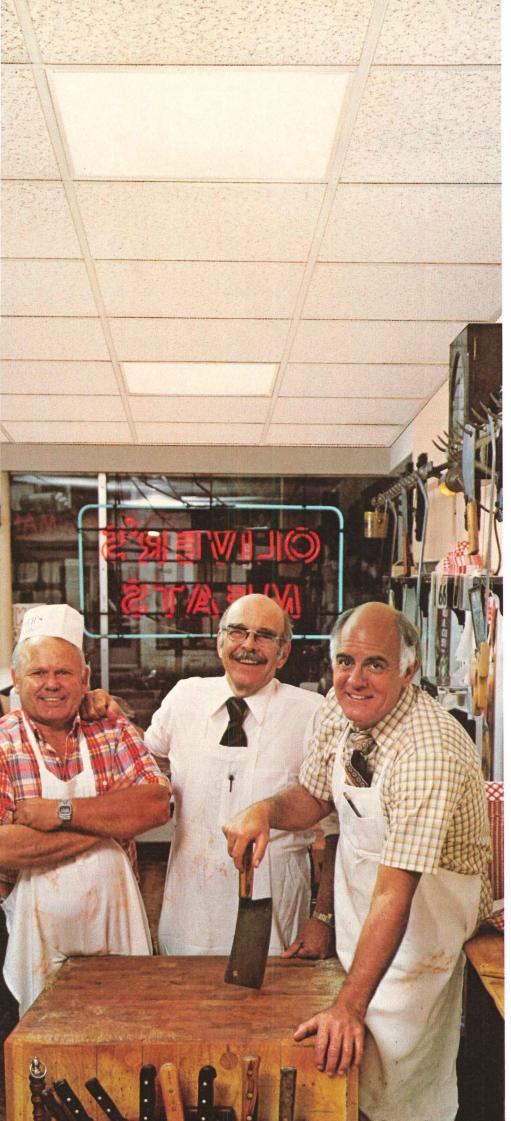


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Johns-Manville

Energy conservation goal of new laws

Norman Coplan

Two new laws encourage energy conservation in buildings, one through tax credits, the other with grants to identify and implement energy-saving measures or develop new sources.

The Federal Government has approached the energy crisis from several different directions. Last year, Congress enacted two significant laws entitled the "National Energy Conservation Policy Act of 1978" and the "Energy Tax Act of 1978," the purposes of which are to encourage the adoption of energy-saving programs, the use of alternative sources of energy, and the alteration of structures to conserve the use of energy. Further, pursuant to the Energy Conservation Standards for New Buildings Act of 1976, the U.S. Department of Housing and Urban Development and the U.S. Department of Energy are developing energy performance standards applicable to commercial and residential buildings which they anticipate will be adopted in August, 1979 to become effective in February, 1980.

The Energy Tax Act of 1978 relies primarily upon tax credit incentives to encourage conservation or to encourage new energy technology. To reduce the consumption of oil and gas by industrial, utility, and institution users, the new law makes the investment tax credit available for the cost of equipment which uses sources of energy other than oil and gas and to related equipment, such as pollution control. This tax credit, which will pay for about 40 percent of the cost of such equipment, is available to businesses, state and local governments, and certain tax exempt organizations. Property eligible for the credit includes equipment which uses as its energy source coal, hydroelectric, nuclear, biomass, geothermal, solar, wind, ocean thermal, and tidal. In addition to the foregoing, the statute provides tax credit for specially defined energy property such as recuperators, regenerators, heat exchangers, waste-heat boilers, automatic energy control systems, preheaters, industrial heat pumps utilized in industrial manufacturing processes, and combustible gas recovery systems. The investment tax credit is also applicable to business insulation property, which is defined as a property which is specifically and primarily designed to reduce heat loss of an existing commercial or industrial building or facility in which the insulation property is installed.

The Energy Tax Act of 1978 also provides for tax credit incentives to home owners to take energy-saving action and to promote the use of solar or wind energy for residential purposes. Expenditures which qualify for tax credit are for energy conservation such as insulation and for a renewable energy source installation, which is defined as equipment which transmits or uses "solar energy, energy derived from geothermal deposits... or any other form of renewable energy which the Secretary spec-

ifies by regulation for the purposes of heating or cooling a dwelling or providing hot water."

The National Energy Conservation Policy Act, also adopted in 1978, authorizes the Secretary of Energy to make grants to the states and to public and private nonprofit schools and hospitals to aid them in identifying and implementing energy conservation maintenance and operating procedures and in evaluating and acquiring conservation measures to reduce energy use of schools, hospitals, and public care institutions. The statute further directs the Secretary to set targets for increased utilization of energy-saving recovery materials in the textile and rubber industries and in the metals and paper products industries. Under this law, the Secretary of Energy is to develop and carry out a program for the installation of solar heating in Federal buildings as examples of the benefit that will result from such technology, and the law further requires each Federal agency to conduct an energy audit of each large Federal facility under its jurisdiction. It further establishes a photovoltaic energy commercialization program for the procurement and installation of photovoltaic electric systems to produce electricity in Federal facilities.

This Act also provides a program by way of grants, loans, and guarantees for the weatherization of rural dwellings occupied by low-income families, for the purchase and installation of energy-conserving improvements by home owners, and for the purchase and installation of energy-conserving equipment and solar energy systems for multiple housing.

In a program aimed at saving energy through the appropriate design of new buildings, HUD and the Department of Energy are developing energy performance standards. The objective of this effort is to incorporate such standards into the requirements for new buildings which receive Federal financial assistance and to encourage state and local governments to adopt and enforce such standards through their existing building codes. These standards will not be prescriptive and will not include any processes, methods, or materials to be incorporated into a building design, nor will they prescribe or prohibit any building design or particular component. The standards will include design energy-conservation goals that must be achieved in terms of energy consumption levels which the design must not exceed. If such performance standards become incorporated in state and local building codes, the architect, who designs a project subject to such code, will be subject to the same professional responsibility, risk, and liability to which he is now subject in respect to building code provisions which are prescriptive in nature. It is, therefore, important, from the viewpoint of the architectural profession, that the standards which are finally promulgated and adopted are viable in the context of the present state of the architectural art.



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r Farm rendering courtesy of McDonnell Douglas Corp

When operational, in 1982, the solar farm will be able to provide enough electricity

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role No. 246 on Donder Carries Card

Products and literature

The following items are related to the articles on conserving energy appearing in this issue. They are grouped by category for the convenience of the reader.

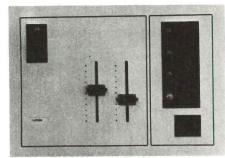
Lighting **Products**

Solid-state light-dimming systems can control incandescent, fluorescent, and/or mercury vapor lamps. The package consists of a dimming cabinet, available with 2500- to 43,200-watt capacity, and intensity controls. Typical applications are lobbies, office buildings, conference rooms, hospitals, convention halls, and restaurants. Lutron Electronics Co., Inc. Circle 100 on reader service card

Sylvania SuperSaver II energy-saving fluorescent lamps provide up to seven percent more light per watt of electricity consumed than the original SuperSaver lamp. A phosphor blend, called Lite-White, delivers 6000 lumens of light in an 8-ft, 60-watt lamp, or 100 lumens per watt, compared with 93 in the earlier model. Used to replace 75-watt standard lamps, the new 60watt units can cut electrical energy usage by 20 percent, according to the manufacturer. General Telephone & Electronics. Circle 101 on reader service card

Maxi-Miser[®] Il electro-magnetic ballast reduces wattage losses and boosts system efficiency. Used in combination with F40 Watt Miser II fluorescent lamps, it is said to permit gains of up to 24 percent in efficiency and savings of up to 19 percent in watts at full light output (11 percent and 5 percent respectively used with 40-watt fluorescent lamps). It is UL listed for Class P ballasts and meets UL standards for core and coil protection. General Electric Co. Circle 102 on reader service card

Parabolume luminaires with baffles direct light to the task, without glare, for visual comfort. They also offer widespread lighting, reducing the number of fixtures required or the number of lamps per fixture. Reduction in electric power usage decreases the load on HVAC equipment.



Solid-state light-dimming systems.

Eight-page, full-color brochure describes the styles available and illustrates their use in various settings. Columbia Lighting, Inc. Circle 103 on reader service card

Automatic Energy Control (AEC) is a method of providing constant-level illumination. Power input is lowered when lamps are new and gradually increased as they age in order to keep lighting at the right level. An optional manual control allows the user to dim lights at times when full lighting is not needed. Outlined in a six-page brochure are the energy and cost savings possible using AEC with mercury vapor lamps, high pressure sodium lamps, and metal halide lamps. WideLite.

Circle 104 on reader service card

The Sylvania Super Metalarc 400-watt lamp, for operation in a base-up vertical position, gives approximately 100 lumens of light per watt (LPW) of electricity consumed. A standard 400-watt metal halide lamp delivers about 85 LPW, and a standard 400-watt mercury lamp approximately 50 LPW. The lamp has a 15,000-hour rated life. Typical applications include gymnasiums, auditoriums, schools, department stores, and industrial locations. General Telephone & Electronics Corp. Circle 105 on reader service card

High Intensity Discharge (HID) lighting fixtures offer energy-saving, highly efficient lighting for institutional and commercial applications. They are said to be up to 40 percent more efficient than fluorescent sources and as much as five times stronger than incandescent lighting. There are three styles of lenses, wattages from 100 to 400 watts, and standard CWA ballast or "Quiet Cube"® potted ballast. Reflectors are highly specular chrome and white enamel combined to provide maximum light output. Halo Lighting Div., McGraw Edison Co. Circle 106 on reader service card

Less™ automatic dimmers sense the arrival and departure of people and turn off or dim lights when there is no one in the area. The dimmers can also control fans, radios, television, and other electrical devices. Potential savings include: lower electricity expenses for lighting; longer lamp life; lower maintenance expense; lower electricity expense for air conditioning because of reduced lighting heat, or smaller air-conditioning units. Novitas, Inc. Circle 107 on reader service card

Energy Conserving Automatic Light Output (ECALO) maintains a selected light level of a fluorescent light fixture by means of sensors that



Guide to energy-efficient HPS luminaires.

measure light output and adjust electricity input accordingly. Instead of overlighting when tubes are new to compensate for lost efficiency, power is used only as required, thus extending tube life. Daylight level is also taken into consideration. ECALO can be used in new installations or retrofitted into existing lighting. Controlled Environment Systems, Inc.

Circle 108 on reader service card

Literature

Guide to energy-efficient high-pressure sodium (HPS) luminaires contains photographs, lighting layout estimating guides, and charts that show cost and energy savings. The 24-page brochure was designed as a planning reference for lighting designers, specifiers, and contractors. It explains payback periods when lighting is changed from fluorescent and mercury lighting to HPS. Johns-Manville Service Center, Holophane.

Circle 200 on reader service card

Energy-efficient lighting for industrial use is provided by the Flexoliner High Intensity Discharge fixture, according to the manufacturer. It accommodates high-pressure sodium, metal halide, and mercury lamps. The four-page Flexoliner brochure contains a dimensional drawing, technical and ordering information, a list of accessories, and illustrated descriptions of the Flex-Loc® method of adjusting light distribution. Westinghouse Electric Corp. Circle 201 on reader service card

Incandescent downlighting catalog provides 94 pages of comprehensive application and specification data about downlighting, accent lighting, and wallwashing installations. Included is an adjustable, retractable unit that adjusts up to 50 degrees vertically and 358 degrees horizontally, or retracts to provide downlighting. There are illustrations, diagrams, charts, and background information about the various lighting units. Lightolier. Circle 202 on reader service card

'Application of Lighting Contactors' to save energy by controlling lighting presents technical information on contactor ratings, types of lighting, their resistance loads, and operating characteristics, as well as various control schemes. Standard and special modifications are listed, and suggested specifications are included in this 16-page bulletin, No. M-504. Square D Co.

Circle 203 on reader service card [Continued on page 185]



To begin with, all joints and sections of Trocal's exclusive multi-chambered PVC window profiles are fusion welded together; precision mitered corners form a smooth, one-piece solid frame and sash. There are no joints to seal, no drafty leaks to plug up. The air locked into the individual chambers adds insulation and prevents condensation.

That's how Trocal windows are shutting out tropical heat, arctic cold, high velocity wind, torrential rain and conserving energy. Even corrosive elements which play havoc with other type windows, have no effect on Trocal. Because Trocal is all PVC—rigid, high impact PVC—not just a vinyl sheath which is often used to improve wood, steel or aluminum. Result: Trocal is completely resistant to salt air, noxious gases and industrial pollution. Shrugs off mortar, lime, cement.

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Send for 8-page brochure, "A New Dimension in Energy Saving"





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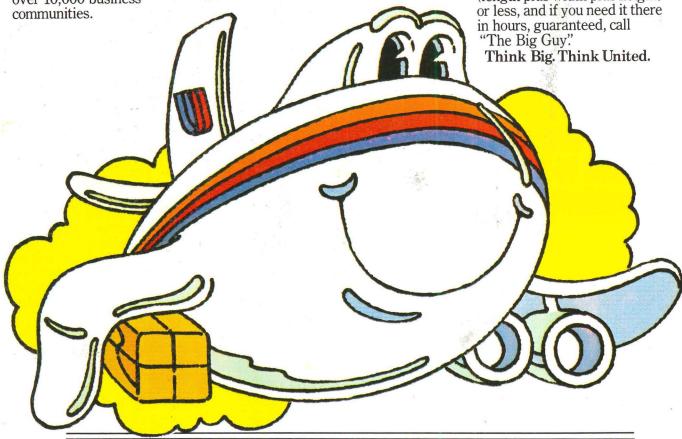
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Products continued from page 182

Solar energy Products

The Solarvent fan, powered by a Solarex photovoltaic panel, moves up to 250 cu ft of air per minute and operates whenever the sun shines. The Unipanel has 12 solar cells that are mounted on a weatherproof substrate and are encapsulated in silicone rubber. The panel generates over six watts in full sun, although 15 percent of full sun provides enough power to start the fan. Solarex Corp.

Circle 109 on reader service card

Eco-Therm solar systems comprise collectors, mounting brackets, pumps of stainless steel, and a control system which turns the pump on when the collector is hotter than the tank. Collectors have Kalwall Sunlite Premium II glazing, aluminum frames, black-coated copper tubing and sheet absorber, and polyurethane insulation. The system can be used to heat pools, spas, and hot tubs, as well as for commercial applications. Horizon Enterprises, Inc. *Circle 110 on reader service card*

Conservationist® solar hot water heaters,

their construction, and how they operate are described in a four-page color brochure. Models are supplied with Phoenix electric backup elements having iron-based superalloy sheathing and ceramic terminals. The heater is available separately, or as part of a complete system. A.O. Smith Corp.

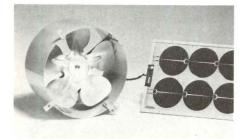
Circle 111 on reader service card

Thermafin® solar energy absorber fintube is said to offer weld strength and service life equal to that of the parent metal. Welding eliminates corrosion, deterioration, and heat transfer loss caused by the use of fluxes and filler metal. Fintube comes in a wide range of materials, sizes, and weights. It is available in single strips or as complete absorber plates. Thermatool Corp. Circle 112 on reader service card

Universal Switching Unit USU-B, for residential and small commercial solar air handling, contains the fan and all motorized valving required for three basic modes of solar operation: heating from collectors, storing heat, and heating from storage. It is a one-piece assembly that facilitates system design and installation. According to the manufacturer, it offers reliable, low-maintenance performance and a cost advantage over other systems on the installed price. Contemporary Systems, Inc. Circle 113 on reader service card

A solar collector for space heating or hot water is designed for optimum operating temperatures up to 170 F. Called Model 1600, it features a black-chrome selective coating, composite insulation, internal manifolds, and high-transmission Solatex glass. Daystar Corp., Solar Systems and Components. Circle 114 on reader service card

Sundirector and Sundirector II are new, direct solar water-heating systems, each engineered for a specific climate. The first has an air space



The Solarvent fan.



Eco-Therm solar systems.

provided for positive draindown and freeze protection. When solar energy is not available, water drains into the storage tank and is replaced by air in the panels and tubing. Sundirector II, for the most southerly states, has an energy-conserving water circulator and an energy-efficient storage tank design. There are three tank sizes for each—66, 82, and 120 gallons—and a choice of five copper panels featuring different glazings, insulation thickness, and absorber-plate surface coatings. Rheem/Ruud Water Heater Divisions, City Investing Co.

Circle 115 on reader service card

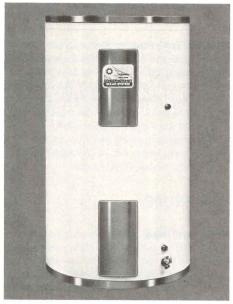
The Solartron vacuum tube solar collector

consists of eight glass vacuum tubes mounted parallel to each other, each at the focal point of a parabolic reflector capable of collecting diffused and direct solar heat. Single tubes can be replaced without shutting down the whole system. The collectors are lightweight, capable of being handled by one man during installation. Support equipment accessories include energy-management module, solar controller, optional protective window, prefabricated header assemblies, and mounting brackets. General Electric Co., Solar Heating and Cooling Marketing, Advanced Energy Programs/Space. Circle 116 on reader service card

The computer-based C-200 control for solar heating and cooling monitors up to six temperature sensors, ten thermostat inputs, and sixteen solid-state outputs. It allows control of solar collectors and storage, domestic water heating, space conditioning with a solar-assisted heat pump, passive solar fans, and auxiliary heating sources. An optional S-200 monitor tests system at startup, simplifies troubleshooting, and permits continuous fine-tuning of the system. Independent Energy Inc.

Circle 117 on reader service card

Sunpump® solar energy collection is suitable for domestic hot water and heating systems using hot water. Collection storage temperatures up to 212 F meet needs of absorption/desorption air-conditioning systems. Focusing



Conservationist solar hot water heaters.

collectors concentrate solar heat on a pipe, vaporizing the water. Energy is transported from the collector as steam. Expansion of the steam causes it to flow to a combination storage tank/heat exchanger where condensation releases latent heat energy for use or storage. Entropy Limited.

Circle 118 on reader service card

Solar energy storage chambers are produced of modular panels adapted from those used on prefabricated walk-in coofers. Panels have foamed-in-place urethane 4 in. thick, with an R-value of 33.90. The panels are held in place with steel straps and have a polyethylene liner. The chambers provide efficient storage for water, rocks, or eutectic salts, says the manufacturer. Bally Case & Cooler, Inc. Circle 119 on reader service card

Solar collector panels in five models are designed with no mechanical fasteners or caulking visible on the face. Frames are bronze, black, or clear anodized aluminum for reduced maintenance. Four of the panels have aluminum absorbers, with a coating guaranteed for 25 years, and tempered, textured, low-iron solar glass. The fifth, a four-panel window, is intended for incorporation into a series of collectors being used as a non-loadbearing wall. It has an adjustable blind in the inner dead-air space. Applications include domestic space heating, water heating, and commercial preheating. Energy Alternatives.

Circle 120 on reader service card

The Mini System for supplementary heating

consists of solar collectors, storage tank, pumps, controls, and a heat extraction grate for the fireplace. It stores heat from the sun and the fireplace for use during the night or on cloudy days. It can be used with an existing forced hot-air system. In addition, a heat exchanger in the storage tank preheats domestic hot water, reducing the length of time required for the water heater to run. Southeastern Solar Systems. Inc.

Circle 121 on reader service card [Products continued on page 186]

Products continued from page 185

Sunsafe® solar transfer fluid is a nontoxic, noncorrosive, and nonflammable water-soluble fluid. As reported by the manufacturer, tests have shown that it eliminates galvanic and other corrosion even when dissimilar metals are used. Sunsafe 300 and Sunsafe 230 are acceptable for solar hot water systems using either double-wall or single-wall heat exchangers. NPD Energy Systems, Inc., KTA Products Div. Circle 122 on reader service card

Literature

Sunstream solar collectors are available in 12 standard models and with many design options. Since they are watertight, they can be used to form the roof membrane. Frames are heavy-duty welded aluminum, and absorber plates are tempered glass with copper tubing. A 20-page brochure provides descriptions, detail diagrams, tables of physical characteristics, and full-color photos of installations in several parts of the U.S. Grumman Energy Systems. Circle 204 on reader service card

'Solcost Space Heating Handbook' consists of four sections: Introduction to the program; a guide to filling out computer form to be processed at a Solcost service center; how to evaluate Solcost output; and a section on technical details. The printout will show optimum system size, size of collector and storage, pumps, ducts, and other components. For a



Sunstream solar collectors.

copy of this handbook, or the Solcost Hot Water Handbook, write on professional letterhead to: Solar Group, International Business Services, Inc., 1010 Vermont Ave., NW, Suite 1010, Washington, DC 20005.

The Sun Catalog is 224 pages of components for energy-saving installations such as collectors, pumps, plumbing connections, fans, blowers, greenhouses, woodstoves, and many other products. Magazines, books, and plans for additional information are listed. Copies of the catalog, at \$2 each, are available from: Solar Usage Now, Inc., 450 E. Tiffin St., Box 306, Bascom, Oh 44809.

Air solar heating manual for architects, engineers, and solar consultants contains step-by-step procedures for designing a Solaron air

solar heating system. Information about system size, design, installation, and operation for residential, commercial, and industrial projects is included. The 175-page manual is \$15. Order from Solaron Corp., 720 S. Colorado Blvd., 300 Galleria Tower, Denver, Co 80222.

The Solar-Kal Airheater, designed to provide heat for residential, commercial, and industrial applications, uses air to transfer heat directly to building spaces or to water storage tubes for later use. It is made up of panels with removable single or double Sun-Lite® polymer covers, a solar air mover with dampers and controls, and storage tubes. It can be used in either passive or active mode. A 44-page "System Design Guide" that discusses components, sizing considerations, procedures, and solar heating references is available for \$15 from Solar Components Div., Kalwall Corp., P.O. Box 237, Manchester, NH 03105.

Solarstrip® is continuously electroplated black chrome on copper that offers lower absorber plate heat losses, higher collector efficiency, and greater Btu output, according to the manufacturer. Data sheet gives information about performance, applications, dimensions, and cost, and compares Btu output of black chrome with that of black paint. Berry Solar Products. Circle 205 on reader service card

'Solar Energy Handbook' provides general guidelines for the design and application of HVAC system controls using solar energy. Several configurations of such systems show [Literature continued on page 190]

What do this Japanese restaurant, furniture store, and office building have in common?

Top — Kyoto Steak House — and right — Barr Office Building, both by Rossen/Neumann Associates, Southfield, Mich. Lower left — Art Van Furniture by Robert L. Ziegelman/Architects, Birmingham, Mich.





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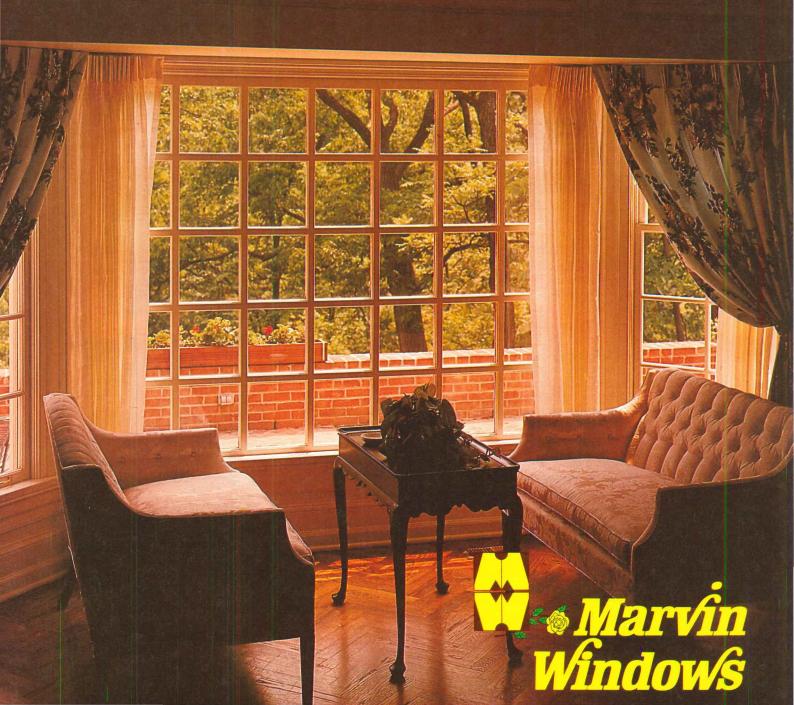
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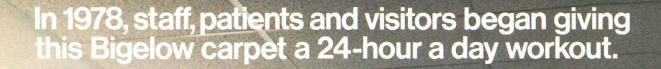


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Literature continued from page 186

how controls are applied to interface solar components with conventional HVAC components. 32 pages. Honeywell, Commercial Div. Circle 206 on reader service card

Silicone materials with 44 applications for solar systems are covered in a 12-page color brochure. Weather resistance, heat resistance, and other properties are discussed. Illustrations show application areas of heat transfer fluids, sealants, paints, lubricants, and elastomers in solar systems. Dow Corning Corp. *Circle 207 on reader service card*

Stainless steel solar collectors are the subject of an article which explains the advantages of using steel in collector panels. Several tables compare properties of types of steel with respect to corrosion resistance, thermal conductivity and expansion, and weather resistance of coatings. Field testing, black chrome coating, and installations throughout the world are also discussed. Molybdenum Mosaic, Vol. 3, No. 3, 1978. Climax Molybdenum Co. Circle 208 on reader service card

'Solar Energy Systems' is a design manual that describes and illustrates various types of solar energy systems. It details different alternatives for collecting, storing, and distributing solar energy for both space and water heating. CDA Sun-Chart Hand Calculations simplify

evaluation of heat loads and collector areas. Single copies of the 50-page handbook are available free. Multiple copies are \$2 each. Write on professional letterhead to: Copper Development Association, Inc., 405 Lexington Ave., New York, NY 10017.

Sun-Pride® domestic hot water heating uses solar energy to heat water. The complete system consists of collectors, pumps, storage tank, thermostat, heat exchanger, expansion tank, and valves. A four-page folder includes a diagram, descriptions of components, and table of suggested collector sizes depending upon family size. Revere Solar and Architectural Products, Inc.

Circle 209 on reader service card

Solar King[®] heat pumps automatically integrate direct solar, solar assisted, and back-up source for space and hot water heating. The system operation is described in a four-page brochure. The collector is illustrated and specification is included, along with a diagram of the system. Performance data and physical data are provided on the major components. American Solar King Corp.

Circle 210 on reader service card

'Passive Design Ideas for the Energy-Conscious Architect' explores several residential design areas in the following sections: Building configuration; Atriums and greenhouses; Using earth to save energy; Dynamic structures; Building envelope; Windows and passive solar collectors; and Interior subsystems. The report was prepared by Professors Walter Kroner and David Haviland of the Renssalaer Polytechnic Institute Center for Architectural Research. The ideas, illustrated and explained, have potential energy savings of 20 to 30 percent. Copies may be had without charge by writing on professional letterhead to: National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, Md 20850.

Suncell® solar heating for industrial process heat and air make-up applications is an air-to-air system. Energy absorbed in the collector is carried to the area requiring heat by means of a blower and ductwork. Four-page brochure shows modes of operation and schematics of the system, and provides information on sizing procedure and technical specifications. Research Products Corp.

Circle 211 on reader service card

Solar energy swimming pool heating is estimated to save from \$300 to \$700 in energy costs per year, depending on size, location, and type of fuel currently being used. Two manuals are offered: Application manual No. 1—Panel area requirement guide for solar swimming pool heating systems, No. 19002, 12 pp., \$2.95; and Application manual No. 2—Solar swimming pool heating system hydraulics, No. 19003, 28 pp., \$4.95. Request copies from Solar Industries, Inc., Monmouth Airport Industrial Park, Farmingdale, NJ 07727.

[Continued on page 192]



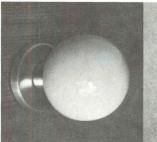
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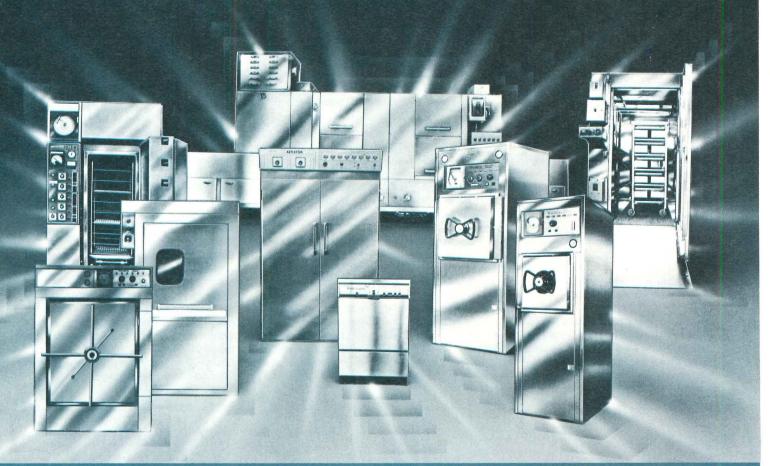
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Products continued from page 190

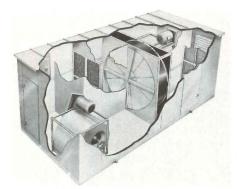
Mechanical systems Products

Zoneline® III extended range heat pumps are through-the-wall units that provide individual room heating and cooling. Available in three models, they have performance ratings of 9100, 11,500, and 14,100 Btuh. Savings compared to conventional resistance heat/cool air conditioners can be anywhere from 22 to 55 percent, depending upon geographical location. They are suitable for both new and retrofit installations. General Electric Co.

Circle 123 on reader service card

Enreco® energy recovery for buildings requiring fresh-air make-up can reduce boiler loads and air-conditioning compressor capacity by as much as 25 percent, according to the manufacturer. Use of the unit permits smaller HVAC system size, reduces fuel consumption, and since it is a packaged unit requiring no field assembly, installation costs are lower. The heat wheel exchanger is capable of recovering both sensible and latent heat. Energy Recovery Co. Circle 124 on reader service card

Zero Energy Band thermostats provide specific heating and cooling setpoints for an adjustable range over which no energy is consumed to maintain space temperature. Model TP978 has a heating range that may be set be-



Zoneline III extended range heat pumps.

tween 60 and 75 F; cooling range between 75 and 90 F. Model TP970 has a single setpoint at the center of the desired range and adjustable stops to limit the range of adjustment allowed to the occupant. Both are adaptable to most new and existing HVAC systems. Honeywell, Inc. Circle 125 on reader service card

Enertech 80 energy management offers predesigned interface control built into heating, ventilating, and air-conditioning components. By monitoring mechanical and electrical equipment, the manufacturer says, building operators can save up to 35 percent. The system compares outside and inside temperatures and computes the amount of heating or cooling time needed to reach preset comfort levels. Also, by assigning priorities to various electrical loads, the operator can shut down those with



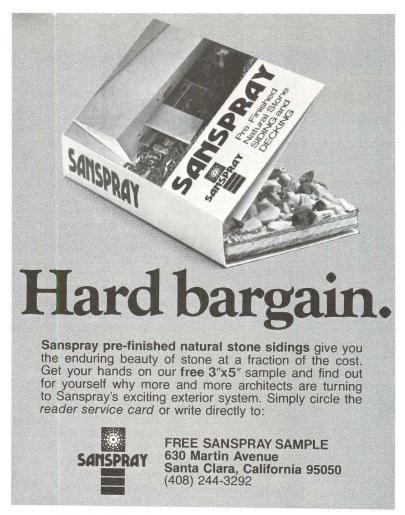
Enreco energy recovery system.

the lowest rating as demands reach peak loads. Included in the control is a means of eliminating unauthorized access to the area. McQuay-Perfex, Inc.

Circle 126 on reader service card

Energy management by computer is offered in several programs. Series/1 Facility Control/ Power Management and Series/1 Supermarket Energy Management are for businesses with energy bills exceeding \$5000. System/7 Programs, for larger, more complex needs, also monitor and control lighting, heating, and air conditioning. As demands reach a predetermined rate, devices are shut down in selected areas that will not interrupt vital services. IBM, General Services Div.

Circle 127 on reader service card [Products continued on page 194]





steel framing saved more than \$150,000 n four-story retirement complex

Local code restrictions for wood frame construction would have limited Casa de los Amigos in Redondo Beach to only three stories, but four stories were needed to provide the desired 136 living units on the land available for this HUD approved senior citizens' project.

In seeking alternatives, a structure combining steel framing on the first floor with three stories of wood framing above was shown to have many problems. The accepted solution, a design prepared with the help of Inryco engineers, used Inryco/Milcor roll-formed steel stud and joist framing throughout. It solved construction problems and also reduced costs by \$155,470.

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Milcor Division; INRYCO, Inc.; Dept. D-4069; P.O. Box 393; Milwaukee, WI 53201.

Inryco/Milcor Steel Framing Systems

Casa de los Amigos, Redondo Beach, California Architect: Arthur Hugh Kensler, A.I.A., Los Angeles, CA General Contractor: J. R. Slaught Construction Co., Irvine, CA Framing Contractor: W. C. Froelich, Inc., Buena Park, CA





Products continued from page 192

A solid state elevator motor drive, Mark V, is estimated to save up to 35 percent in elevator power cost, with machine-room space saving of 40 percent. Weight savings are said to be as much as 50 percent, which can reduce construction costs. The unit has a programmable solid-state control system that controls up to eight cars in a bank of elevators, and it can be reprogrammed as needs change. Westinghouse Elevator Co.

Circle 128 on reader service card

Heat consumption meters that attach to radiators, baseboard units, or other heating surfaces allocate costs of heating energy in apartments, condominiums, and cooperative apartments more equitably. The company also manufactures thermostatic valves to automatically regulate heating for even room temperature and to balance a heating system. Another control regulates flow and temperature of heating water according to outdoor temperature. Ista Energy Systems Corp.

Circle 129 on reader service card

Automated building control systems. JC-80 is a computerized control system. One operator at a single-unit console monitors and controls all building systems: heating, ventilating, cooling, fire safety, security, and sound systems. The control center also stores information about energy use which can be retrieved to show

where energy can be reduced. The installation can pay for itself in as little as three years through energy savings alone, according to the company. An analysis sheet and energy survey service are also offered. Johnson Controls, Inc. Circle 130 on reader service card

SunPath® heat pumps in 7½- and 10-ton models are designed for energy-efficient heating and cooling of commercial buildings. The roof-top units have bottom duct connections, but there are concentric or end discharge options. Supply and return duct kits are available accessories. York Div., Borg-Warner Corp. *Circle 131 on reader service card*

Energy-integrated air conditioning that can be interfaced with all types of available energy sources, including solar, provides a more comfortable environment with reduced requirements for space and energy, at cost savings. Humidity from outside air is removed and rejected to cooling-tower water or other area that is not energy intensive, thus lowering the air-conditioning load. According to the manufacturer, chilled water temperature can be raised from 42 F to 55 F. The system provides constant spatial air movement with individual zone control. Ross Air Systems Div., Midland-Ross. Circle 132 on reader service card

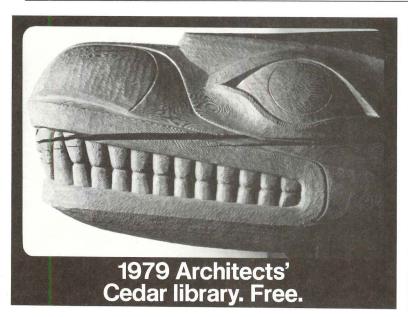
Co-Ray-Vac heating is a series of ceilingsuspended burners, connected by piping, which radiate heat. Metal reflectors over the pipes direct heat downward, and an exhauster draws heat through the system, expelling products of combustion. Factors contributing to what is said to be a 50 percent more efficient system are high combustion efficiency, less heat stratification, comfort at lower temperatures, and reduced building heat loss. The heaters are suitable for offices or showrooms, movie theaters, and restaurants. Roberts-Gordon Appliance. Circle 133 on reader service card

Literature

'Energy Efficient Space Conditioning' provides data based on actual performance tests as a guide to installation of evaporative cooling systems. The manual includes formulas for calculating correct cooler size and determining energy use. According to the company, independent tests show that evaporative coolers require less energy than other cooling systems. International Metal Products Div., McGraw-Edison.

Circle 212 on reader service card

Fan-forced and radiant auxiliary heaters for residential use provide spot heating for areas where extra warmth is desired, without the need for increasing heat throughout the structure. Models combined with ceiling lighting and ventilating, infrared heating lamps, wall models, and other heaters are described and illustrated in a 12-page brochure. NuTone Div., Scoville. Circle 213 on reader service card [Literature continued on page 196]



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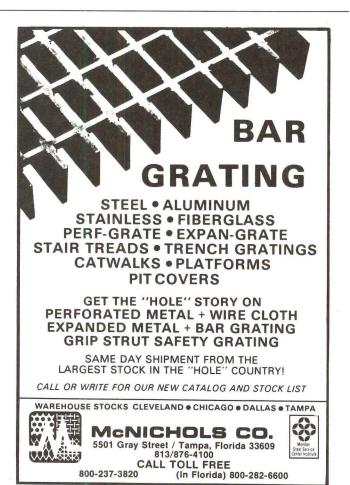
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Today's need for energy-conserving buildings makes concrete the designer's logical choice. Concrete lends itself naturally to design which is highly creative-and at the same time-can be dramatically energy-efficient. For example, the Lincoln Library (shown here) has a concrete building envelope that contributes to the overall efficiency of the building. Concrete walls, limited glass area, sun shading and reflective surfaces combine to form an envelope that dramatically reduces the heat load of the building. What's more, when used throughout, concrete's design integrity provides pleasing visual continuity and contributes long-term investment advantages. Mail the coupon. We'll send you more information about designing for energy conservation with concrete.









ASSOCIATION Old Orchard Road, Skokie, IL 60077 312/966-6200. Ext. 366 Dept. PA-49 Write for details on how the buildings shown here took advantage of concrete design to save energy.

NAME_ COMPANY **ADDRESS** CITY STATE ZIP

- Basin Electric Cooperative, Bismarck, N.D. Architect: Ritterbush Associates
- Zora Neale Hurston Building, Orlando, Fla. Architect: Lewis and Burke Associates,

- Terraset Elementary School, Reston, Va. Architect: Davis, Smith and Carter Arizona Bank Building, Phoenix Architect: Kelley-Marshall Associates Lincoln Library, Springfield, Ill. Graham, O'Shea and Wisnosky, Architects & Planners Inc. Architects & Planners, Inc.

Literature continued from page 194

Rational Energy Analysis Procedure (REAP) is an automated analysis program for building energy systems. Information is fed into a computer using a standard calculator keyboard, and responses are in English. Using local meteorological data, the operator can calculate design heating and cooling loads, refrigeration machinery energy consumption, and energy used by other HVAC components. The energy and life-cycle costs of large or small, new or existing projects can be determined with this program. Carrier Air Conditioning.

Energy management for institutions. Two publications of the Department of Health, Education and Welfare are "Total Energy Management for Hospitals" (HRA 77-614, 92 pp.) and "Total Energy Management for Nursing Homes" (HRA 78-613, 72 pp.). Both are aimed at energy conservation by making building systems as efficient as possible. Plans for developing a program of energy management include analyzing energy used, surveying systems for faults, developing and implementing a plan for conservation, and monitoring the plan. Guidelines indicate modifications that can be made to improve operating efficiency. Worksheets are included. Request copies, by title and number, from Department of Health, Education and Welfare, Public Health Service, Health Resources Administration, Hyattsville, Md 20782.

Heat recovery computer analysis service,

available to those involved in HVAC for plants, and commercial and institutional buildings, determines the optimum design of coil run-around waste-heat recovery systems. Provided with the volume and temperature of both exhaust air and intake ventilation air, the computer will determine the number and size of coils and rate of flow of solution used in this type of system to obtain maximum heat transfer and maximum reduction in fuel consumption. American Air Filter Co., Inc.

Circle 215 on reader service card

Building envelope Products



Residential skylights.

Residential skylights to provide light and ventilation can be installed in new or existing buildings. The assembly includes copper flashing, double-insulated acrylic dome, curb liner, and fiberglass screen. It is operated by a chain that can be controlled by hand, pole, or motor. Ventarama Skylight Corp.

Circle 134 on reader service card

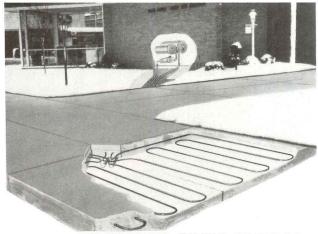
Energy-saving ceilings as a means of cutting heating and cooling costs are discussed in a 16-page brochure. There are panels, boards, and insulating batts that can be used in existing ceiling grids. A step-by-step procedure to follow for estimating savings possible is provided, as well as a worksheet showing an example based on an actual building. Owens-Corning Fiberglas Corp., Building Products Operating Div. Circle 135 on reader service card

Thermawall foil-backed rigid urethane insulating panel permanently bonded to gypsum board is designed for use on interior walls, and on vaulted ceilings in residential construction. It is applied with the Thermawall nailless fastening system, that avoids nail penetration of the panels. Rmax, Inc.

Circle 136 on reader service card

Architectural artwork from the past, engineered for today.

Insul-Aid® vapor barrier latex paint is applied to interior walls and ceilings to help protect insulation against moisture. According to the manufacturer, it reduces the flow of water vapor through relatively porous construction materials. [Products continued on page 198]



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The patented Hume system sets state-of-the-art performance standards for in-ground automatic snow melting. So reliable, it's backed by a full five-year pipe system warranty. Our latest illustrated brochure contains full details and system specifications. Send for your copy today.



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ova, an exceptionally comrtable, stacking chair, can ter to the upscale image of corporate ning rooms, or stand up to the panemonium of teen agers in cafeterias and assrooms.

Nova. A three-year guarantee.

ova's unique cross-frame design minates the need for easily-breakable elded connections found in many her systems.

So after successfully testing it in over 60,000 sittings, each up to 220 pounds, ithout any damage, we offer a three-year ructural guarantee on each chair.

The shell, molded in either nylon or olypropylene, is light enough to move, et heavy enough to provide extra rength and durability. And unlike ninted metal shells, the color is integral, a scratch on the surface only reveals e same color underneath.

When Gerd Lange designed the Nova system in 1970, winning one of Germany's is waiting leading design awards, he planned for

almost every option.

You can order upholstered pads that can be replaced right on the premises, chair-stacking dollies, ganging frames, tandem units with or without tables, tandem riser mounts (for theater riser steps), fixed pedestal bases (that bolt into the floor), book racks, glide feet, tablet arms, removeable-top tables, tabletop dollies, even a variety of ashtrays.

But if you're ingenious enough to think of something more, we can probably make it on special order.

Nova. It's parked everywhere.

Since its invention in 1970, Nova has sold by the tens of thousands all over the world.

Mt. Sinai Hospital, The University of Alaska, the Guggenheim Museum and the Largo Library use it.

When Pan Am flies into J.F.K., Nova

Prudential Life, Bell Telephone, Holiday Inn, and Zip'z ice cream parlors use it. And, of course, Cuyahoga Vocation-

al High School.

So whether your clients include the carriage trade or the galloping herds, Nova is the best parking place you'll find.

For more information about Nova write or visit Atelier International, 595 Madison Avenue, N.Y., N.Y. 10022. Or phone us at (212) 644-0400. Our complete catalog of furniture, lighting, art and accessories is available upon request. Some major credit cards accepted.

For your convenience, we have additional showrooms in Chicago, Dallas, Los Angeles, Atlanta and Seattle; sales offices in Boston, Cincinnati, Detroit, Houston, Miami, Philadelphia, Pittsburgh, San Francisco, Washington, D.C. and selected furniture dealers nationally. Member ASID, IBD, BIFMA.

Products continued from page 196

Applied at 400 sq ft per gallon, the paint has a moisture permeability rate of 0.6. Quick drying time permits topcoating in four hours. Glidden Coatings & Resins, Div. of SCM Corp. Circle 137 on reader service card

Sunwall® solar windows are made of heatand pressure-bonded Sun-Lite® fiberglassreinforced polymer faces on extruded aluminum grid core. The translucent panels are effective insulating, weathertight covers for walls or roofs which transmit solar energy. They can operate as solar windows for passive solar systems or can provide a weatherproof covering for active or passive collectors. The 4-ft- or 5-ft-wide panels are suitable for industrial or residential applications. Kalwall Corp.

Circle 138 on reader service card

LLamar® solar control window film conserves energy, eliminates ultraviolet damage, and improves the safety of ordinary glass. Applied to the inside of window glass, the film reportedly can cut cooling costs up to 30 percent. The polyester film is available tinted, with or without metalizing. Martin Processing Inc., Film Div. Circle 139 on reader service card

Hollow Macrospheres are made up of 75 percent hollow glass bubbles and 25 percent phenolic resin binder. About one-quarter the size of a grain of salt, the tiny spheres flow easily and are generally static-free. Used as insulation, a 1-in. thickness will provide an R factor of 3. Since they can be easily moved, they can be pumped elsewhere when heat gain from the sun is desired, and pumped back to prevent loss of heat in the absence of sun. 3M Company. Circle 140 on reader service card

Roof deck systems made of perlite concrete/ polystyrene have two-hour fire rating and U-values as low as 0.040 Btu/hr/sq ft/F. Fourpage catalog discusses the application, physical property data, and weight comparisons with other roof types, with details of six different designs. Guide specification is included. Perlite Institute, Inc.

Circle 141 on reader service card

Roof insulation of urethane core, bonded with asphalt-saturated felt skins, kraft-paper skins, or asphalt-saturated felt top and perlite base, can be used in built-up roofing systems. Depending on type and thickness, R-values range from 6.67 to 22.22. Tapered, felt-skinned roof insulation is also available. NRG Barriers, Inc. Circle 216 on reader service card

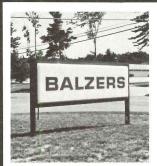
Gaftemp lightweight, rigid insulation board is composed of expanded perlite particles blended with binders and fibers. The top is sealed with a special coating to retain the proper amount of mopping bitumens and to help assure positive adhesion of the built-up roofing membrane. It is usable over nailable, non-nailable, or metal roof decks. It offers dependable thermal insulation and dimensional stability during seasonal wet/dry and hot/cold cycles, according to the manufacturer, and is usable with hot and cold adhesives. GAF Corp. Circle 217 on reader service card

Literature

Vari-Tran®-coated glass screens out heatproducing sunlight in commercial, industrial, and institutional buildings to reduce energy costs. A six-page color brochure illustrates buildings that use this glass and the tints available. Tables show transmittance, reflectance, U-value, and shading coefficients of the various coatings on monolithic, Thermopane, laminated glass, and triple Thermopane. Libbey-Owens-Ford Co.

Circle 218 on reader service card

Settef exterior wall insulation and finish can be used on wood stud frame, metal stud frame, masonry, or concrete walls. The expanded polystyrene board is adhered to the surface with a mixture of portland cement and primer/ adhesive. Reinforcing fabric is embedded on the face in a layer of the adhesive/cement, following which the desired Settef finish is applied by trowel. There are over 100 colors and four major textures available. Additional information about the system is provided in an eight-page brochure. Compo Industries, Inc. Circle 219 on reader service card [Literature continued on page 203]







ELEVATOR

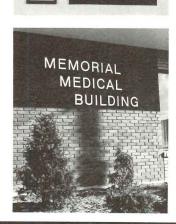
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Practical is an important part of being beautiful, especially in this day and age. That's why the window blinds you prefer to specify for their looks, are also the

ones that can work hard to conserve energy. Levolor Riviera, and Galaxy Sun Controller Blinds. For complete specifications write for the new edition of Levolor's Architects' Manual.

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LEVOLOR® BLINDS Riviera Galaxy

Eight ingenious ways to save energy, even in a bitter cold New Hampshire winter.

This is the new Norris Cotton Federal Building in Manchester, New Hampshire. Here, where the winters are long and icy, energy conservation is a must.

Today, in fact, the federal government is setting performance standards for energy conservation in all of its buildings. This one was specially designed as a prototype to demonstrate many energy-saving features.

To the architects, Nicholas and Andrew Isaak of Manchester, this was an unusual design challenge.

The material selected was masenny.

The material selected was masonry.

Because masonry has the mass and density to make it more thermally efficient than other materials, it keeps heat in during winter months and heat out during summer months. According to the General Services Administration, this masonry building is estimated to save 53 percent of the energy that would be used by a conventionally

constructed building of the same dimensions.

Now, read about some of the design features of this building that can save energy and money on other buildings:

- The shape, as cubical as possible, minimizes wall area exposed to elements unlike more traditional rectangular buildings.
- The massive north wall has no windows, and core elements (stairs, elevator shafts, toilets, etc.) are located adjacent to north wall. This, of course, is a masonry wall.
- The window area is only 12 percent of the other three walls.
- The mass (weight) of the masonry exterior walls (100 lbs. per sq. foot) takes maximum advantage of thermal storage. Walls are granite veneer, insulation, 12-inch concrete block.
- 5. A light-colored roof serves as heat reflector.
- Windows are shaded by fins. Fin size varies with orientation of facade.
- The lighting systems are designed for minimum impact on inside heating and cooling systems.
- 8. Solar collectors, which augment the heating system, have been installed on the roof.

If you would like more information on the energy-saving performance of masonry, write IMI.



Nicholas Isaak and Andrew Isaak, Architects Davison Construction Co. Local 6, New Hampshire, BAC



823 15th Street, N.W., Suite 1001 Washington, D.C. 20005 (202) 783-3908

Circle No. 360, on Reader Service Card

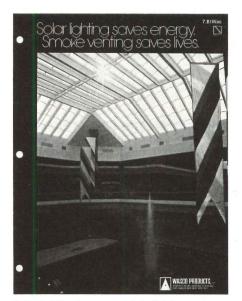
Literature continued from page 198

Solar lighting by means of skylights helps to reduce use of electrical energy. Domed models catch light earlier in the day and later in the evening than flat types do. Colder areas require double glazing to reduce heat loss. A 16-page brochure shows styles available, custom-designed installations, and heat and smoke vents. Company also offers a solar lighting computer analysis. Wasco Products, Inc. Circle 220 on reader service card

'Use Solar Daylight & Heat' is a 20-page brochure that illustrates the ways in which windows can be used to take advantage of daylight and sun to provide light and heat gain. In addition, there is a table of insulating values of single- to quadruple-glazed windows. Graphs show single- and double-glass window area influence on heating and cooling requirements. PPG Solar Products Dept.

Circle 221 on reader service card

Roof insulation to meet insulation needs, code requirements, and principal fire insulation classifications is produced in five types. Thermax® is isocyanurate foam board with glass fiber reinforcement for use on steel decks requiring Factory Mutual Class 1 approval. Tempchek®, a urethane foam plastic insulation board, can be used either over or under a roof membrane. Celo-Therm® is perlite roof insulation board that is lightweight, resistant to moisture, and has good insulation value. Tempchek Plus®, a composite board of perlite and urethane foam for



Solar lighting by means of skylights.

use over steel decks, is approved for Factory Mutual Class 1 construction. Fiberboard is a wood-fiber general purpose roof insulation board. Descriptions, property tables, and advantages of each are given in a 12-page brochure, along with specifications. Celotex Corp.

Circle 222 on reader service card

'Energy-Saving Aspects of Levolor Blinds.'
Savings figures given in this report are based on a comparison of installations using clear glass and heat-absorbing glass, each with and

without blinds. Tables compare initial investment, estimated annual energy requirements, and 20-year life-cycle costs for each of the four types of windows. Potential for lower capital investment because of reduced loads is also considered. Levolor-Lorentzen. Circle 223 on reader service card

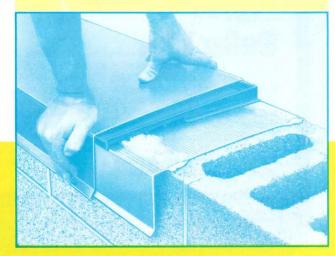
Wall systems with thermal isolation features and air infiltration control offer energy conservation. A four-page color brochure describes and illustrates these and other features of Series 100 and 400 curtain walls. Howmet Aluminum Corp. Circle 224 on reader service card

'Earth-Integrated Building Construction' discusses methods of building entirely underground, into hillsides, or with earth berming. The report touches on the history of underground building and reasons for current interest, and presents photos and drawings of and data about several such buildings. Recommendations for underground construction cover planning to avoid water infiltration, insulating effects of various depths of earth, drainage, waterproofing, and moisture control. Request Report CR056.01B, at \$1.50 each, from: Portland Cement Association, 5420 Old Orchard Rd., Skokie, II 60076.

Zonolite® insulation products for walls are: Thermo-Stud, with patented metal furring channel, for interior walls; masonry insulation, lightweight, free-flowing granular vermiculite to be poured into cores and cavities of masonry walls; and styrene foam, expanded polystyrene [Literature continued on page 204]

Guaranteed Parapet Protection ...it's a "snap" with Hickman.

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After the galvanized cleat and special chair are mounted on the masonry, the Hickman Coping Cover simply "snaps" in place. There are no nails, no wood nailer, no screws, no imbedded anchor bolts. The PERMASNAP System is guaranteed waterproof . . . and withstands 60 pounds per foot uplift. For fast, effective protection plus good looks, specify PERMASNAP Coping by Hickman. See us in Sweet's (7.3 Hi).

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(704) 274-4000

Literature continued from page 203

to insulate foundations, walls, and roofs. The three are described in a 20-page brochure that includes photos of products being installed, detail drawings, and specifications. W.R. Grace & Co., Construction Products Div.

Circle 225 on reader service card

Windows and gliding doors. This 52-page 1979 catalog of windows and gliding doors is expanded to include a technical support section that features a reference chart of glazing options available. Also included are data on insulating values, heat gain, air infiltration, and testing procedures. Models include vinyl-clad windows and doors, as well as primed and prefinished types. Andersen Corporation. Circle 226 on reader service card

Thermocore® evaluation of built-up roofing

combines infrared remote sensing with on-site inspection. Infrared scanning by air indicates areas of water infiltration into the insulation, with the extent of damage determined by visual inspection of the roof. A written report of the roof's condition identifies areas requiring either repair or replacement. The service is described in a four-page brochure. Tremco.

Circle 227 on reader service card

Styrofoam® RM insulation protects single-ply roofing membranes from ultraviolet light, temperature cycling, and physical abuse. Crushed

stone provides ballast and a surface for foot traffic. The insulation is suitable for upgrading thermal insulation of existing roofs. Four-page folder also includes information on the installation of this insulation over liquid membrane systems. Dow Chemical U.S.A.

Circle 228 on reader service card

Comparison of heating and cooling costs.

Charts in this 28-page booklet aid in calculating U-values for roof and wall systems of various types of construction. Table shows median temperature extreme, average winter temperature, and annual degree days for several cities in every state. Sample problems illustrate how to calculate heating and cooling costs using information from the charts and table. Armco Building Systems.

Circle 229 on reader service card

'Energy: How to conserve it when you build' is an 18-page booklet that discusses planning a building to save energy and costs. Insulation, roofs, and walls are considered from this standpoint, and information is provided about how Butler buildings are constructed for energy efficiency. Butler Manufacturing Corp.

Circle 230 on reader service card

Building materials

Major materials suppliers for buildings that are featured this month as they were furnished to P/A by the architects.

Pitkin County Airport Terminal (p. 120).

Architects: Copland Finholm Hagman Yaw Ltd., Aspen, Co. Concrete spread footings: Martin Marietta. Glu-Lam post and beam: Intermountain Beam Co. Concrete masonry units: Valley Building Supply. Concrete slab on grade: Martin Marietta. Wood joists: Boise Cascade. Earth and glass: Thermoglass of Denver. Wood wall surfacing: Valley Building Supply. Concrete floor surfacing: Martin Marietta. Acoustical textured gypsum wallboard: U.S. Gypsum. Asphalt roofing and dampproofing: Johns-Manville. Insulation blankets: Owens-Corning. Interior roof drains: Wade. Aluminum window frames: Northrup Architecture. Overhead rolling door: Overhead Door Co. Hardware: Schlage. Paint and stain: Olympic. Wood benches: J.G. Fluorescent light fixtures: Universal. Plumbing and sanitary: Universal-Rundle. Forced-air heating: Trane Manufacturing. Solar: Zomeworks

Plant Science Building, Millbrook, NY (p. 124). Architect: Malcolm Wells, Brewster, Ma. Solar panels: Chamberlain Mfg. Corp., KTA Products Div., NPD Energy Systems. Chiller/heat pump: Dunham-Bush Inc. Evaporative condenser:Baltimore Air Coil Co. Air-handling units: Trane. Solar water pumps: Weiman Pump Co. Automatic control system: Robertshaw Controls Co. Plumbing fixtures: American Standard. Plumbing fittings: Richard Fife Co., Sloan Valve Co. Electrical distribution: ITE Corp. Fire alarm: The Edwards Co. Lighting fixtures: Lam, Alco, Miller, Lite Control, Daybrite, Prescolite, Omega, Smithcraft, Crouse Hinds, Moldcast, Benjamin, Lightolier.





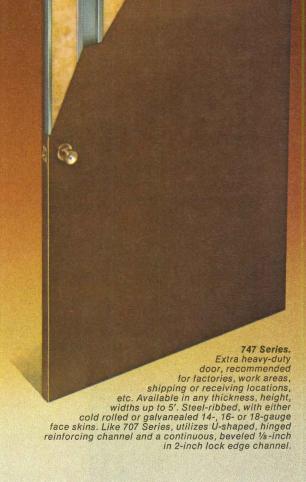
energy saving skylights are manufactured by Faulkner Plastics incorporating both PLEXIGLAS® acrylic and LEXAN® polycarbonate glazing materials. Clear or solar control tints are available. A comprehensive range of standard and custom sizes and styles are offered with single, double, and triple glazed construction. The new patented TRI-THERM® units offer the maximum available in energy saving plastic skylight values. Also included in the brochure are detailed physical characteristics including thermal transmittance (U values) and condensation factors. A brochure which illustrates canopy or walkway covers on a custom order basis is also available. Faulkner wants to be your skylight company.

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In short, more ways to satisfy your needs without having to get into custom manufacturing.



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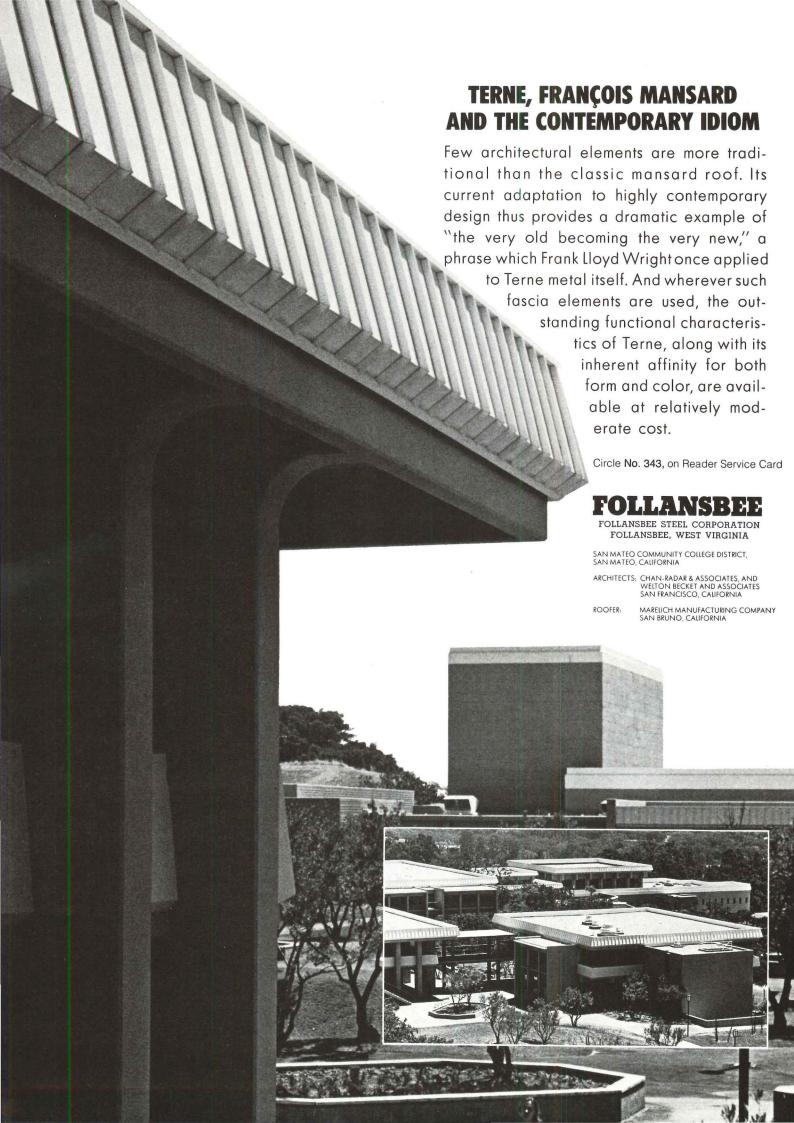
For more details, call him. (He's in the Yellow Pages.) Or see Sweet's 8.2/Cur.

Curries Manufacturing Inc., 251 9th St. SE, Mason City, Iowa 50401. (515) 423-1334.

Circle No. 331, on Reader Service Card









"We figured we could save the MGM Grand Hotel \$8,000,000 in future energy costs.

Only E CUBE had the capability to confirm our analysis."

That's the conclusion of Consulting Engineer Frank T. Andrews of Fullerton, California, who's had long experience in dealing with Las Vegas hotel complexes. When he was given the MGM Grand Hotel energysaving assignment, Andrews knew that because of the many variables and intricacies involved, the job required a computer solution with a flexible input format and almost unlimited scope. After investigating several energy analysis programs, he selected E CUBE because it was the best way to:

· Quantify energy saving techniques.

· Measure life cycle dollars saved by conserving energy.

· Analyze existing buildings and systems, allowing them to be modeled exactly.

- Critically examine large complex buildings.
- Model exactly an infinite number of zones with complex exterior surfaces.
- Accomplish the energy analysis at low computer running cost.
- · Secure impartial results.

Future savings: \$8,000,000.

In recommending the best program for MGM Grand, and simulating the most appropriate series of conservation options, Frank Andrews was able to verify that:

- · Chilled water pumping horsepower could be increased to adequate size and controlled to reduce electric consumption.
- Oversized variable air volume system in low rise building areas was wasteful and should be renovated.
- Existing fan coil units for tower

guest rooms were inadequate for optimum guest comfort.

· Economy cycle cooling for public spaces in conjunction with airside balancing should be implemented. Modifications to air conditioning

procedures in some of the Hotel's 53 individual zones were indicated. With these and other improvements, the savings in energy costs to the MGM Grand, taking inflation

factors into account, is projected to be in the area of \$8 million over a 25-year life cycle.

Other advantages of E CUBE.

Saving money

important reason for using E CUBE, but not the only one.

E CUBE is private—your project data and results are never seen by a third party.

E CUBE is a comprehensive system-it computes the hour-by-hour energy requirements of your building, or planned building for an entire year, taking into account all weather, design, operation and occupancy factors.

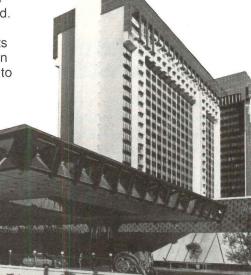
E CUBE allows the design engineer to control the results by his input of performance efficiencies.

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"We selected the Gold Bond I-Stud Cavity Shaftwall System because it saves us up to 20% on each job over conventional systems and is easier to install. It offers many advantages over traditional methods of shaft enclosure", says Bill Martin, president of Martin Brothers Plastering Co. of Gardena, California.

The Gold Bond I-Stud Cavity Shaftwall Systems, like the one the Martin Brothers firm installed in this 12-story Cedar Sinai Medical Center office building in Los Angeles, is an economical alternative to cinderblock, plaster, and standard steel stud and drywall enclosures for elevator shafts, stairwells and vertical chases. Savings in time, space and weight are impressive.

A two-man drywall crew can install the system, floor-to-floor from the corridor side, without scaffolding or special rigging . . . in any weather.

The metal I-Stud, with exclusive built-in tabs for continued visual alignment and engagement checks during installation, and the "J" Track for runners at top and bottom are the only major components. Together they assure positive engagement and alignment of the 1" Fire-Shield Gypsum Coreboard panels. The noncombustible system has a 2-hour fire rating and achieves STC ratings of up to 51.

A finished enclosure, including two face layers of %" Fire-Shield Gypsum Wallboard, weighs only about 10 pounds per square foot of wall. And the system withstands positive and negative air pressure created by high-speed elevators.

For more answers that can make a big difference to you, contact your nearest Gold Bond Representative, refer to Sweets General Building File 9.6/Go, or mail the coupon for Construction Guide 8599.

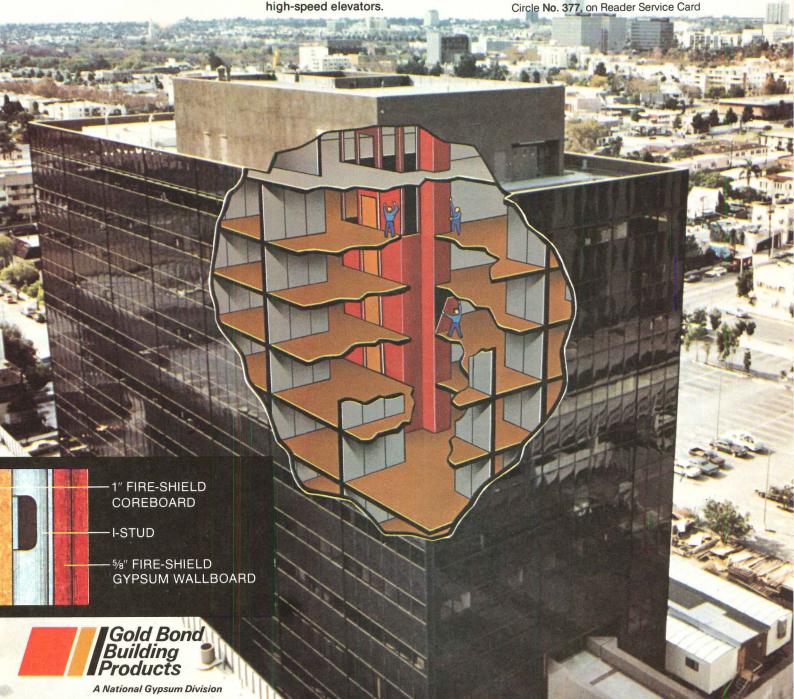
Mail to:

Gold Bond Building Products
Division of National Gypsum Company
2001 Rexford Road, Dept. PA
Charlotte, North Carolina 28211

Please send free Construction Guide 8599 on
I-Stud Cavity Shaftwall System.

Have a Gold Bond Representative contact me.

Name______ Title ______
Company______
Address ______ State _____ Zip _____
Phone (Area Code ___)



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Architect: Expanding architectural firm seeking architect or apprentice with 3 years experience minimum to accept position of responsibility covering all phases of practice. Send resume and samples of work to: Architects Design Group, 350 Garfield, Lander, Wy 82520. An Equal Opportunity Employer.

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Architectural Marketing Representative: A major midwest design oriented A-E firm has opening for a representative to serve architectural marketing and client contact requirements in institutional and governmental areas. Architectural background desirable but not mandatory. Excellent opportunity for growth with firm. Submit qualifications in confidence to Box 1361-269, *Progressive Architecture*. An Equal Opportunity Employer.

Assistant Professor: University of Maryland School of Architecture. Asst. Prof., to teach structures to architectural students and to assist in the development of new graduate M.Arch. program and development of School's curriculum in technology; begin Fall 1979; some experience in both teaching and practice desired; appropriate master's degree required; reply to Roger K. Lewis, School of Architecture, University of Maryland, College Park, Md 20742. The University of Maryland is an Equal Opportunity Employer.

Architectural Designer: Able to handle working drawing & delineation, with Bachelor of Architecture. Salary \$850/mo. 40 hr/wk. Contact: Richard Stahl, AlA Architect, 614 South Avenue, Springfield, Mo 65806.

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Environmental Historian: University of Texas at Arlington, School of Architecture and Environmental Design. *Environmental Historian*, rank and salary negotiable. Ph.D. preferred. Share responsibility for large survey course; teach course in History of Landscape Architecture; develop upper division and graduate courses in field of specialty; supervise graduate theses. Send vita and references to Dean George S. Wright, SAED/UTA, Arlington, Tx 76019

Faculty of Architecture: This university faculty of architecture, which presently comprises a School of Architecture and Department of Urban and Rural Planning, totaling about 200 students, seeks applications to teach the use of computers in architecture and to contribute to design and other courses. Relevant professional or research experience and post-professional higher degree mandatory. Appointment at Associate or Assistant Professor levels (salary minima about \$25,000 and \$20,000 respectively). Canadian citizens, landed immigrants or holders of valid work permits from the Employment and Immigration Commission will be given preference. Resume with names and addresses of three referees to: Dr. Peter Manning, Dean, Faculty of Architecture, Nova Scotia Technical College, P.O. Box 1000, Halifax, N.S., Canada

Faculty: The School of Architecture, University of Maryland, College Park, MD 20742 seeks candidates for two or more design faculty positions at junior or senior levels. Responsibilities: teaching one design studio course and one elective or required course per semester. Send resume before March 15, 1979, to Professor Heather Cass, Chairman of Search Committee for Design. The University of Maryland is an equal opportunity employer.

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Faculty: Univ. of III. @ Urbana-Champaign, Dept. of Arch. has 5 fac. pos. open August 1979. 1) Assoc. or full prof. to guide grad design thesis studio

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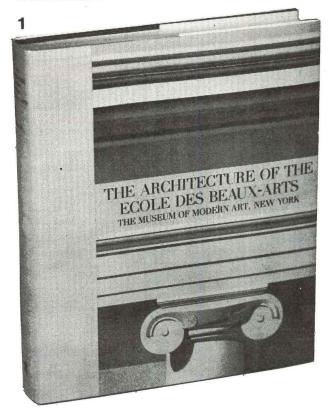
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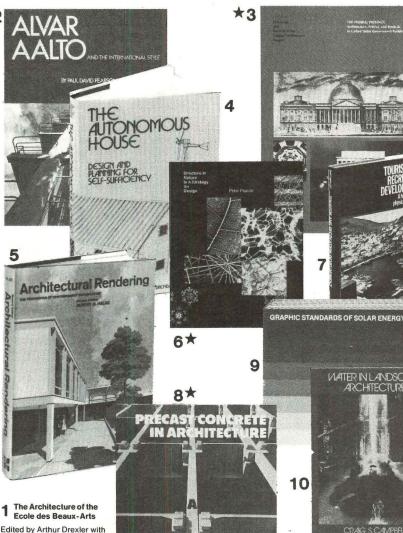
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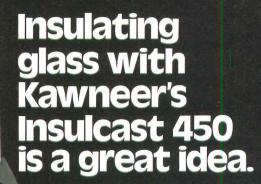
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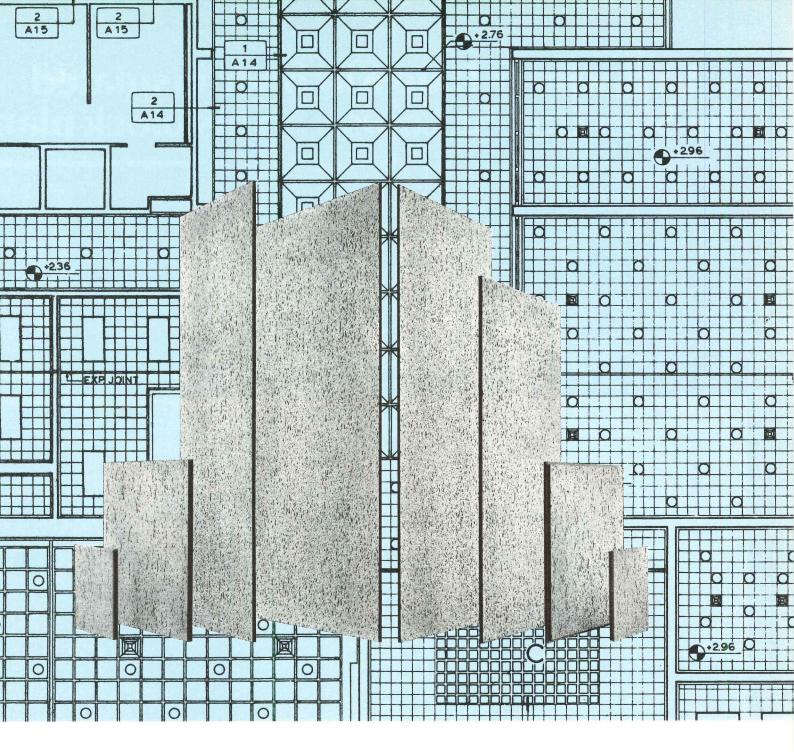
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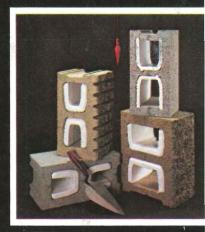
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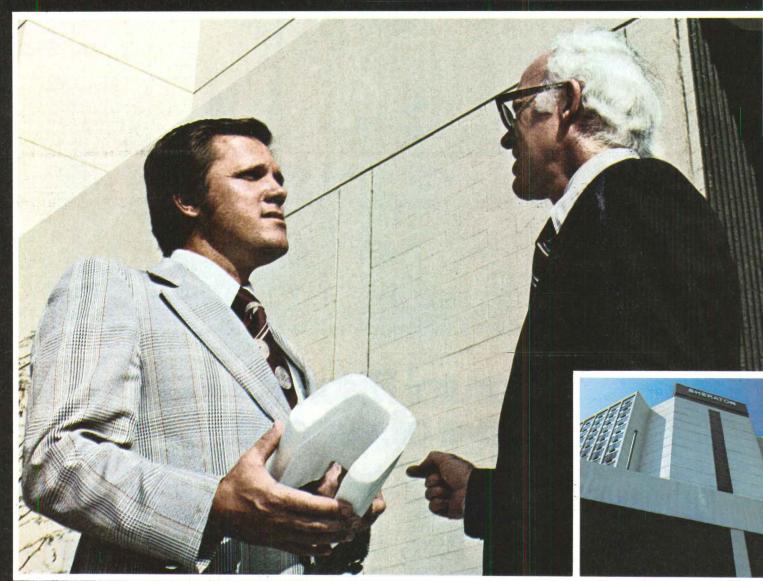
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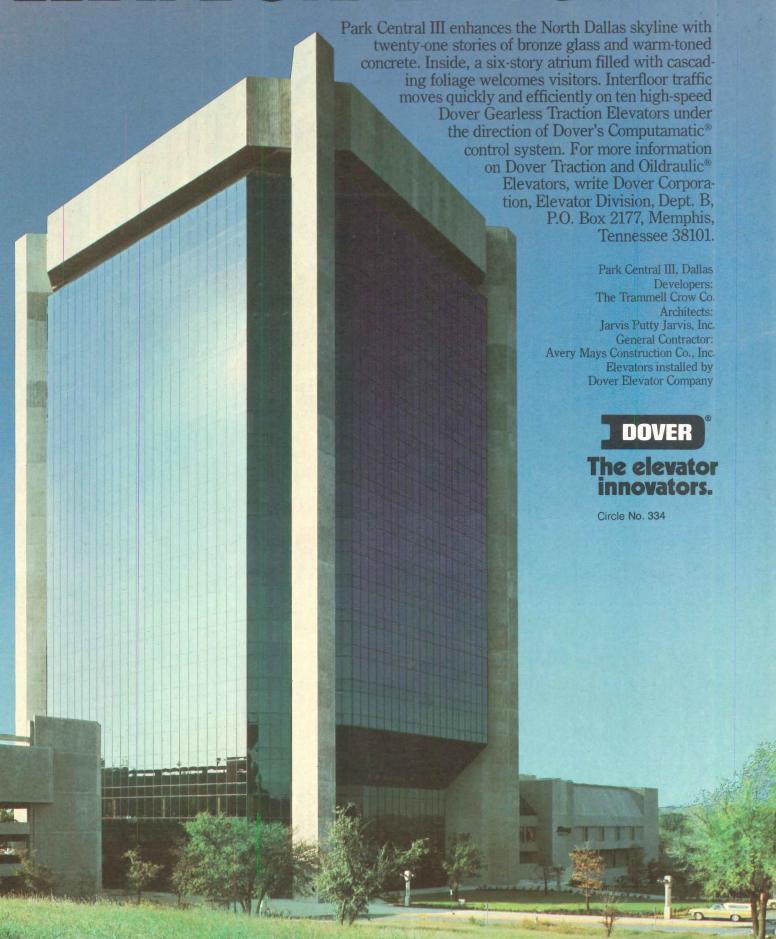


Dale Kirchner, Kirchner Industries (left) with H. Shelby Pruett, Jr. Executive V.P. Spire Corporation, design firm of the new Sheraton St. Lo



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